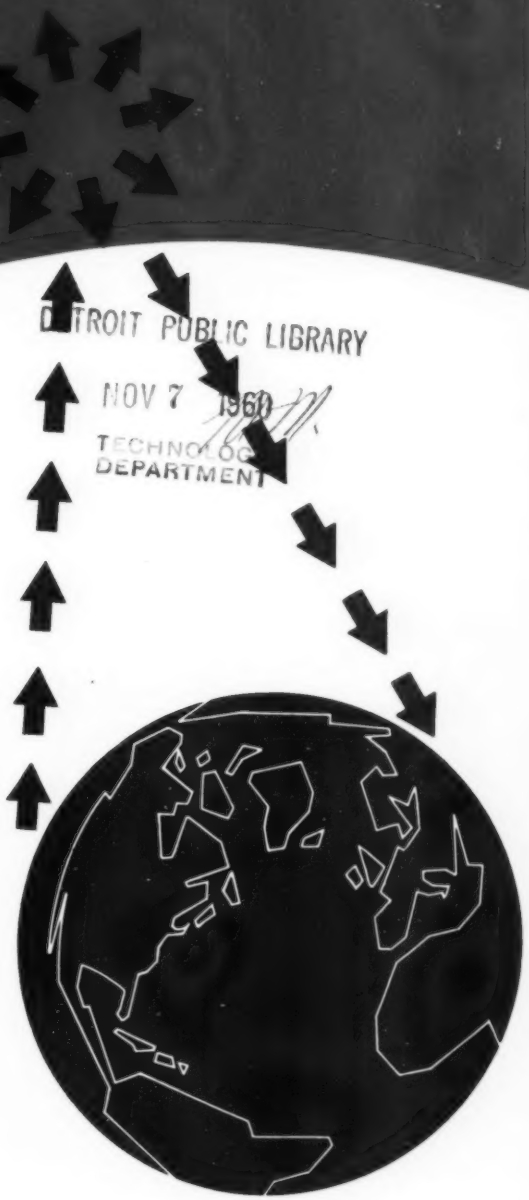
Technology Review

11.63 #1



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November 1960: M.I.T. Prepares for Its Second Century

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. . . a quiz for Chemical Executives who want to keep posted

QUESTION 1. According to a recent survey by the Manufacturing Chemists Assn., nearly 50% of its members are engaged in, or have an interest in, foreign operations. Can you guess what per cent of total capital outlay by U.S. chemical companies in 1959 was for plants and facilities overseas?

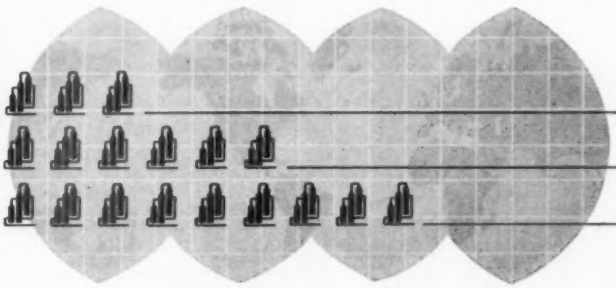
a $$$$$ ——— 5%

b $$$$$$$$$$ ——— 10%

c $$$$$$$$$$$$$$ ——— 15%

d $$$$$$$$$$$$$$$$$$$$ ——— 20%

QUESTION 2. How many chemical and petrochemical plants has Lummus designed, engineered and/or constructed abroad since World War II?



a ——— 31

b ——— 61

c ——— 91

ANSWERS: 1. *(c) is correct. MCA reports that an estimated 15% of the money spent by U.S. chemical companies in 1959 went for plants and facilities overseas.*

2. *The answer is (b). Lummus has designed, engineered and/or constructed 61 chemical and petrochemical plants in 11 foreign countries since 1945. Seven international members form the Lummus group of companies which circles the globe.*

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Technology Review

Reg. U.S. Pat. Off.

Volume 63, Number 1 *Edited at the Massachusetts Institute of Technology* *November, 1960*

Feedback

More on Math for Kids

FROM ROBERT B. DAVIS, '46:

If you read the Technology Review carefully, you may know that an article of mine appeared in the December, 1959, issue, describing some experiments in teaching relatively advanced mathematics to relatively young children. In the March, 1960, issue, my friend and former teacher, Prof. Philip Franklin, has written a cogent account of his reasons for believing that my work and that of my colleagues may well be headed in a conspicuously erroneous direction.

I now write, therefore, in a pleased and friendly spirit. Academic disputation being an indoor sport that appeals to me greatly, finding myself challenged by an opponent whom I admire is more than I could have dared expect. Let us even overlook, for the moment, the fact that I agree with a great deal of what Professor Franklin writes. We can, if we try, find some grounds for disagreement.

There seem to be two questions in dispute: first, is it wise "to use boxes," i.e., to write $3 + \square = 5$ in place of the traditional $3 + x = 5$; and, second, is it reasonable to suppose that children can discover for themselves the quadratic formula, or the concept of *slope*, or the fact that

$$\int_0^\infty e^{-x^2}\,dx = \frac{\sqrt{\pi}}{2}.$$

I may have phrased these questions badly. If I understand the alternatives correctly, we are asking: Is it better to use, for a time, notation that youngsters find self-explanatory (but many adults find abhorrent), in order to get quickly at important mathematical ideas—or, is it preferable to begin with the standard notation from the very outset?

The second question is apparently this: Is it possible (and worth the ef-

(Continued on page 46)

ALDOUS HUXLEY, *author of* Brave New World *and many other novels, is Carnegie Visiting Professor of Humanities at M.I.T. this fall. In addition to giving a series of public lectures, he is conducting the Humanities Senior Seminar. Mr. Huxley also will participate in the exercises next spring marking the Centennial of the Institute.*

EDITOR: Volta Torrey; BUSINESS MANAGER: R. T. Jope, '28; CIRCULATION MANAGER: D. P. Severance, '38; EDITORIAL ASSOCIATES: J. J. Rowlands, Francis E. Wylie, John I. Mattill; EDITORIAL STAFF: Ruth King, Muriel R. Roberts, Norma G. Humphries; BUSINESS STAFF: Madeline R. McCormick, Marianne G. Hagerty; PUBLISHER: H. E. Lobdell, '17.

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Second-class postage paid at Concord, N. H.

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Individuals Noteworthy

Electrical Engineering Department's Head

PROFESSOR PETER ELIAS, '44, became head of the M.I.T. Department of Electrical Engineering last July 1. He has been a member of its Faculty for seven years, active in its educational programs, and at the age of 36 is widely known as an authority on information theory. His notable contributions to this field have included work on predictive coding, error-correcting codes, the exploitation of the notion of "individual information," and methods of utilizing feedback to simplify coding.

Professor Jerome B. Wiesner, who served last year as Acting Head of the Department, is devoting his energies now to the development of the Research Laboratory of Electronics and the Center for Communication Sciences.

The new head of the Institute's largest Department entered Swarthmore College in 1940 and transferred to M.I.T. as a junior in 1942. After receiving his bachelor's degree in Industrial Management, he served two years in the U.S. Navy, then continued his studies at Harvard University, receiving the master of science degree in 1948, the master of engineering science degree in 1949, and his doctorate in 1950. He held a teaching fellowship at Harvard between 1948 and 1950, and from 1950 to 1953 was a junior Fellow of the Society of Fellows. He joined the M.I.T. staff in 1951 as a guest of the Research Laboratory of Electronics, and was appointed assistant professor in 1953, associate professor in 1956, and professor in 1960. He was a visiting lecturer in electrical engineering in 1958 at the University of California at Berkeley.

He is a member of Sigma Xi, Eta Kappa Nu, the Institute of Mathematical Statistics, and Commission VI of the International Scientific Radio Union, and a Fellow of the Institute of Radio Engineers. Professor Elias is co-editor of the journal *Information and Control*, and has written on information theory for other journals. He also has served E. I. du Pont de Nemours & Company, the Polaroid Corporation, and Baird-Atomic, Inc., as a consultant.

Professor Peter Elias, '44

Professor and Mrs. Elias, the former Marjorie Forbes, and their three children live in Cambridge.

Corporation Members

LAURANCE S. ROCKEFELLER, chairman of Rockefeller Center in New York, and George P. Edmonds, '26, chairman of the Wilmington Trust Company, in Wilmington, Del., have been elected to special five-year term memberships on the M.I.T. Corporation.

Three other prominent business executives became alumni term members of the Corporation last July 1. They are Bennett Archambault, '32, chairman of the board and President, Stewart-Warner Corporation, Chicago; Semon E. Knudsen, '36, Vice-president of the General Motors Corporation and general manager of the Pontiac division; and Robert H. Winters, '33, President of the Rio Tinto Mining Company of Canada, Ltd., and a former member of the Canadian Cabinet.

Whitman's New Post

ON LEAVE of absence from M.I.T., Professor Walter G. Whitman, '17, became science adviser to the U.S. Secretary of State last August. He was Secretary General of the United Nations International Conference on the Peaceful Uses of Atomic Energy in 1955, and had previously served the nation in many capacities. He was a member of the General Advisory Committee to the Atomic Energy Commission from 1950 to 1956 and of the Office of Defense Management's Science Advisory Committee from 1951 to 1955, chairman of the Research and Development Board of the Department of Defense from 1951 to 1953, and a member of the National Advisory Committee for Aeronautics from 1951 to 1953.

Professor Whitman first joined the Institute's staff in 1917. For nine years he was associated with the Standard Oil Company of Indiana, then returned to the Institute in 1934 as Head of the Department of Chemical Engineering.

Dr. Draper's Aide

HAVING RETIRED from the U.S. Navy this year after 20 years' service, Comdr. Samuel A. Forter, '47, has become assistant director of the M.I.T. Instrumentation Laboratory. He is working with its director, C. Stark Draper, '26, on advanced design and development of the inertial guidance system for Polaris, the Navy's 1,200-mile ballistic missile.

Commander Forter was graduated from the U.S. Naval Academy in 1940, and served on ships in both the Pacific and European theaters during World War II.

In Physical Education

EDWARD A. CROCKER, a member of the Department of Athletics staff at M.I.T. since 1957, became director of physical education this fall. In addition to coaching the varsity tennis and squash teams, he now administers the comprehensive physical education class activities involving about 3,000 undergraduates.

(Continued on page 6)

A GIANT STEP FORWARD IN STEAM CONDENSER DESIGN

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Individuals Noteworthy

(Continued from page 4)

New Posts

NAMED in the news recently were the Alumni whose elections, promotions, and appointments follow:

Barnett F. Dodge, '17, as Dean, School of Engineering, Yale University . . . *John O. Bower, '22,* as President and Chief Executive Officer, Colsag Corporation . . . *James W. Kinnear, Jr., '22,* as Vice-president, Steel Producing Divisions, United States Steel Corporation;

Irving Whitehouse, '22, as Director of Research, Republic Steel Corporation . . . *Sydney S. Dean, '23,* as Secretary, Building Owners and Managers Association, Greater Boston Real Estate Board . . . *David W. Skinner, '23,* and *C. Vincent Vappi, '48,* as President and as Vice-president, respectively, of the Cambridge Chamber of Commerce;

William P. Lowell, Jr., '26, as Manager, Technical Liaison, Sylvania Lighting Products Division, Sylvania Electric Products, Inc. . . . *F. Edward Anderson, '27,* and *Robert L. McCormack, '33,* as Director, Commercial Regional Offices, and as Vice-president, respectively, Raytheon Company;

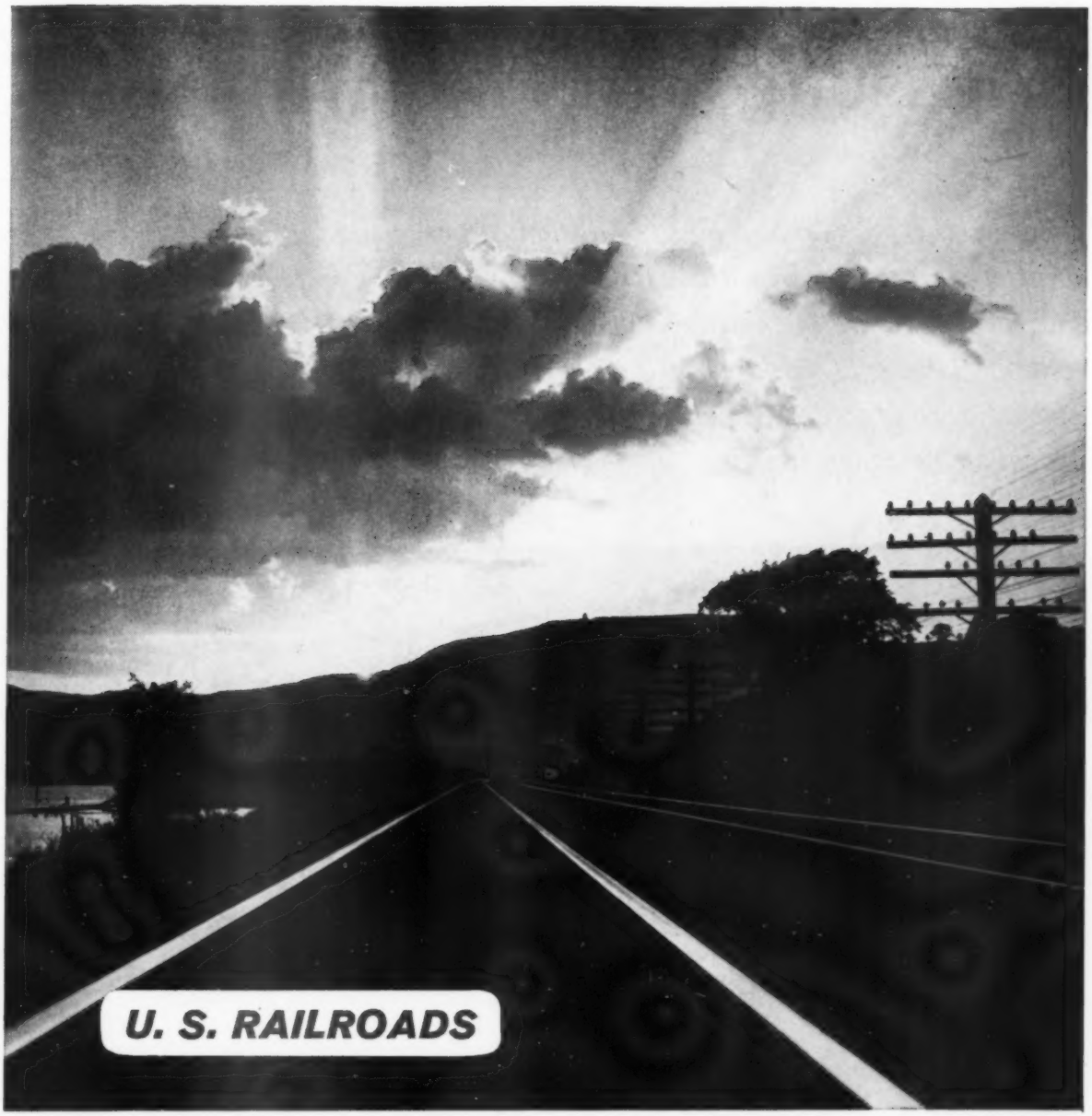
Theodore E. Casselman, Jr., '27, and *Edgar M. Hawkins, Jr., '30,* as Vice-presidents, Stone & Webster Service Corporation . . . *Edward R. Stevens, '28,* as President, Baldwin-Ehret-Hill Company, Inc. . . . *Eric A. Bianchi, '29,* and *Paul Wing, Jr., '34,* as General Manager, and as Manager of Engineering, respectively, Mason-Neilan Division, Worthington Corporation;

Paul V. Keyser, Jr., '29, as Executive Vice-president, Socony Mobil Oil Company . . . *Charles T. Abbott, '30,* as Vice-president, Operations, NEGEA Service Corporation . . . *Edward L. Mears, 2d, '30,* and *J. Wade Miller, '48,* as Vice-presidents, Dewey and Almy Chemical Division, W. R. Grace & Company;

Carl F. Baker, '31, as Quality Manager, Chandler Evans Corporation . . . *Edwin J. Ducayet, '31,* as President, Bell Helicopter Company . . . *James B. Fisk, '31,* as a Director, American Cyanamid Company;

Claude F. Machen, '31, as a Director, Boston Gas Company . . .

(Continued on page 10)



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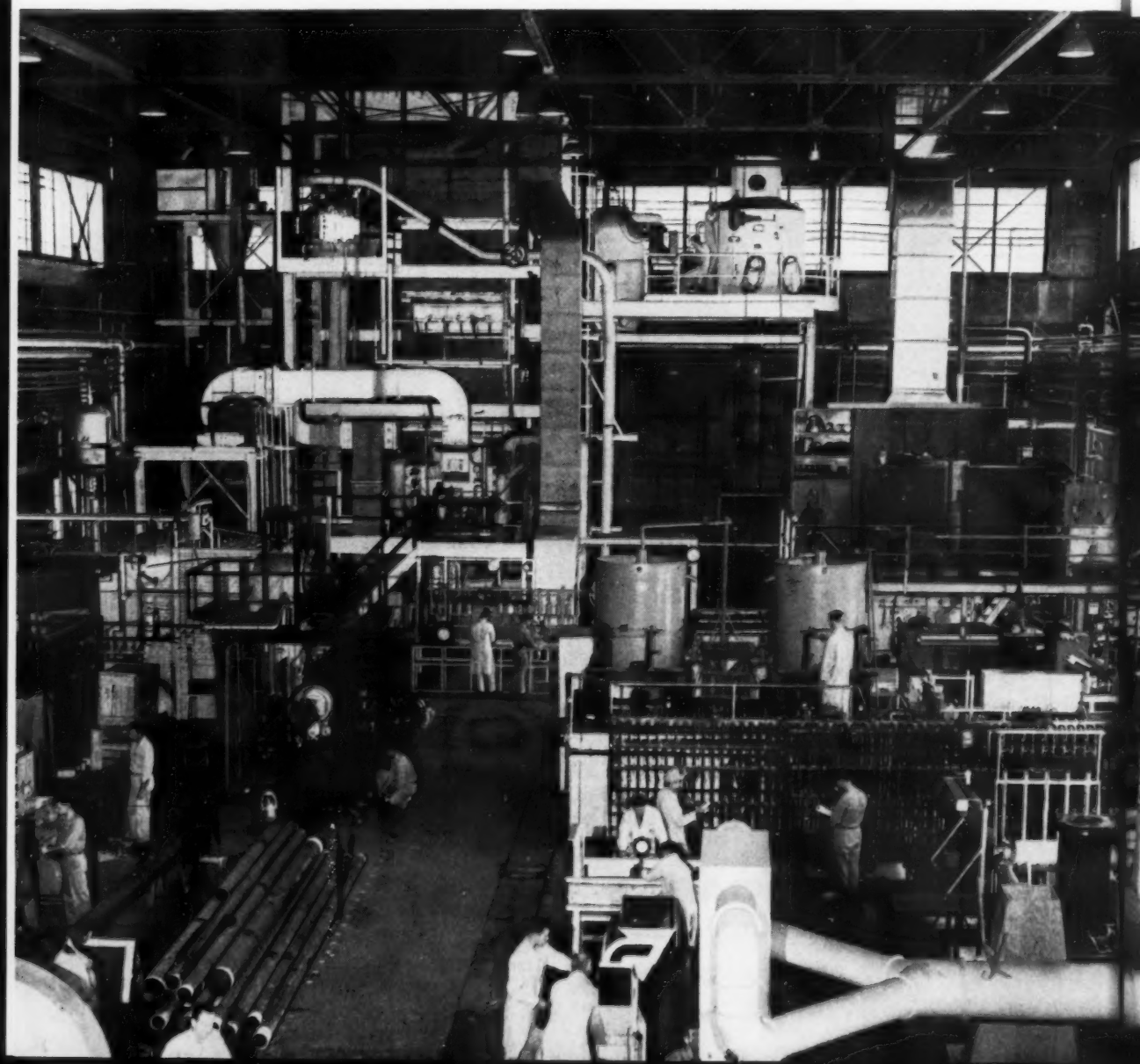

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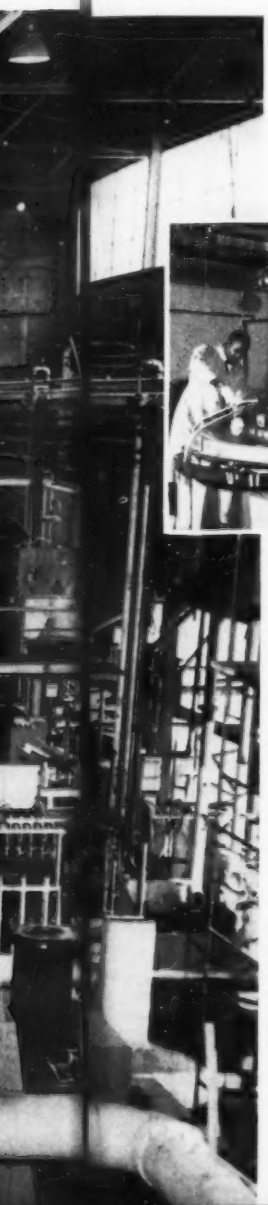

THE KREISINGER DEVELOPMENT LABORATORY is used for the study of fuels and fuel burning systems, water, steam and combustion gases. It contains several test boilers, among them a large Controlled Circulation unit capable of operating at 2000 pounds pressure and a super-critical pressure boiler designed to produce steam at 5000 pounds pressure and 1200°F. This laboratory is one of eight C-E research facilities which, together, total more than four acres under roof.

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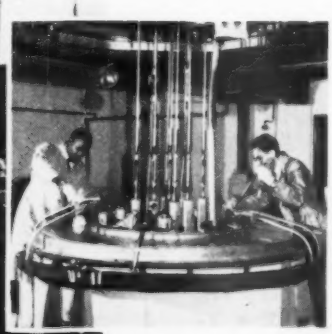

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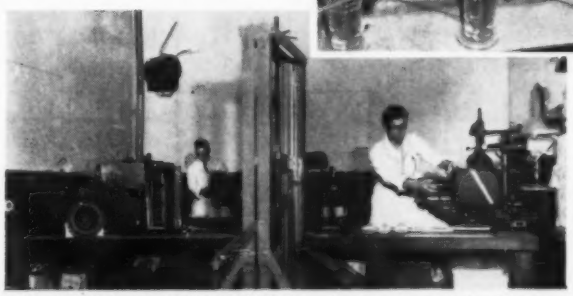

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Individuals Noteworthy

(Continued from page 6)

Gilbert M. Roddy, '31, as a Director, Merchants National Bank, Boston . . . *Ivan A. Getting, '33,* as President, Aerospace Corporation, El Segundo, Calif.;

Franklin P. Parker, '36, as a Director, Wellesley Trust Company . . . *Brigadier General Alvin C. Welling, '38,* as Director of the Construction Office, Ballistic Missile Complex, U.S. Air Force, Inglewood, Calif. . . . *Herbert A. Finke, '39,* as Director, Long Range Product Planning, Varian Associates;

Howard H. Reynolds, '39, and *Austin W. Fisher, Jr., '41,* as Vice-presidents, Ludlow Papers and Ludlow Plastics Division, Ludlow Corporation, Needham Heights . . . *Paul N. Stanton, '39,* as Vice-president, Marketing, Pratt and Whitney Company, Inc.;

William M. Hearon, '40, as Vice-president, Research and Development, Crown Zellerbach Corporation . . . *Julius P. Molnar, '40,* as Vice-president, Bell Telephone Laboratories . . . *Albert H. Bowker, '41,* as President, Institute of Mathematical Statistics;

Walter J. Robbie, '42, as Vice-president, Eaton Paper Corporation . . . *Morton F. Spears, '43,* as Vice-president, Engineering, Pick-

(Continued on page 56)

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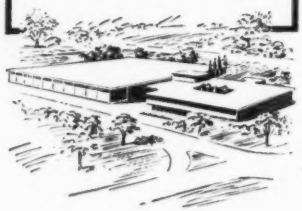

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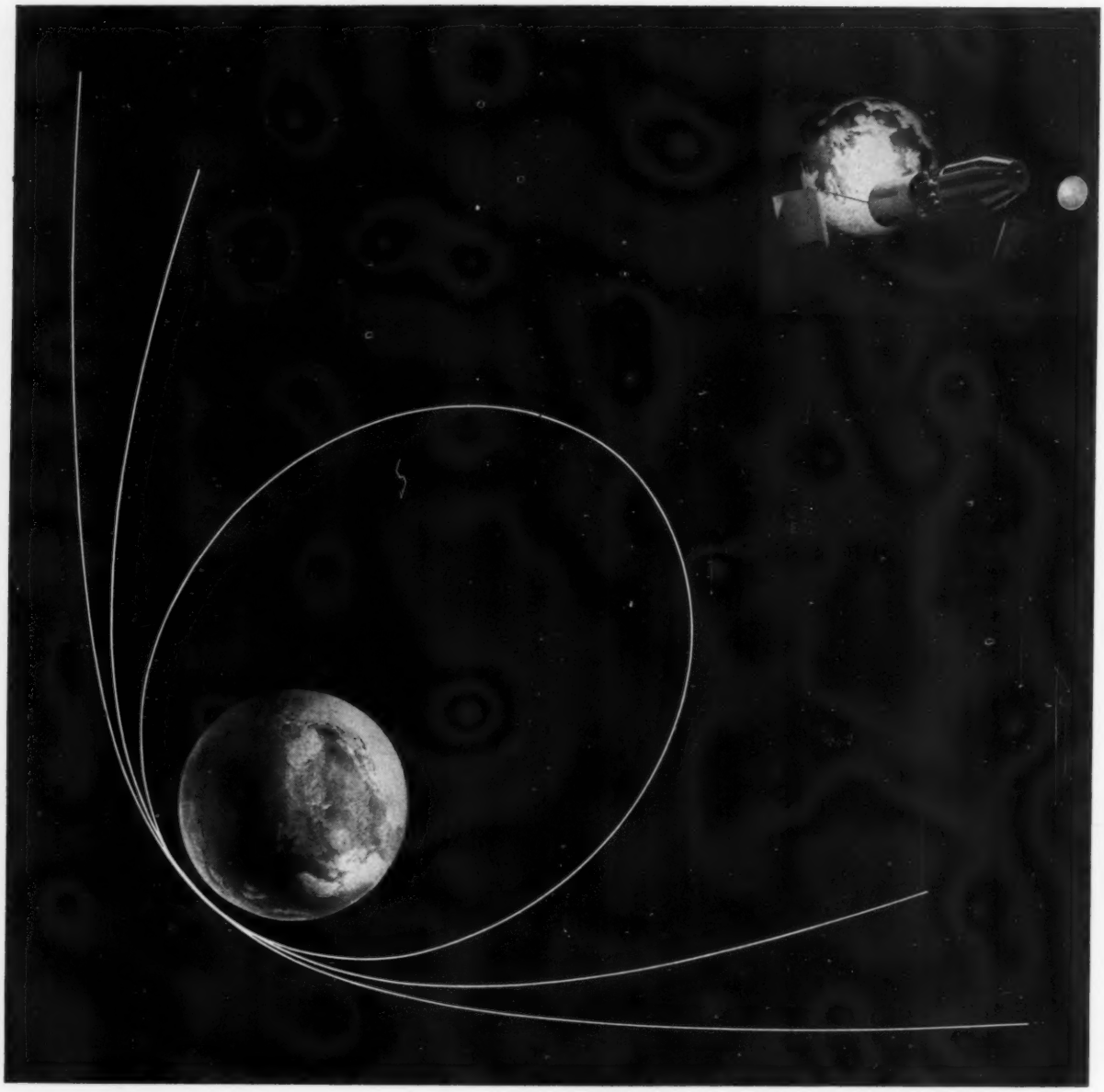

Orbits through space

The space-flight paths diagrammed above represent a closed elliptical orbit, a parabolic orbit, and, on the outside, an open, hyperbolic orbit characteristic of the start of an interplanetary flight.

Orbital flight mechanics is one of the many areas of advanced investigation at Boeing. The staff of the Boeing Scientific Research Laboratories, for example, carries out basic research in such fields as energy conversion, hypersonics, magneto-hydrodynamics and plasma physics.

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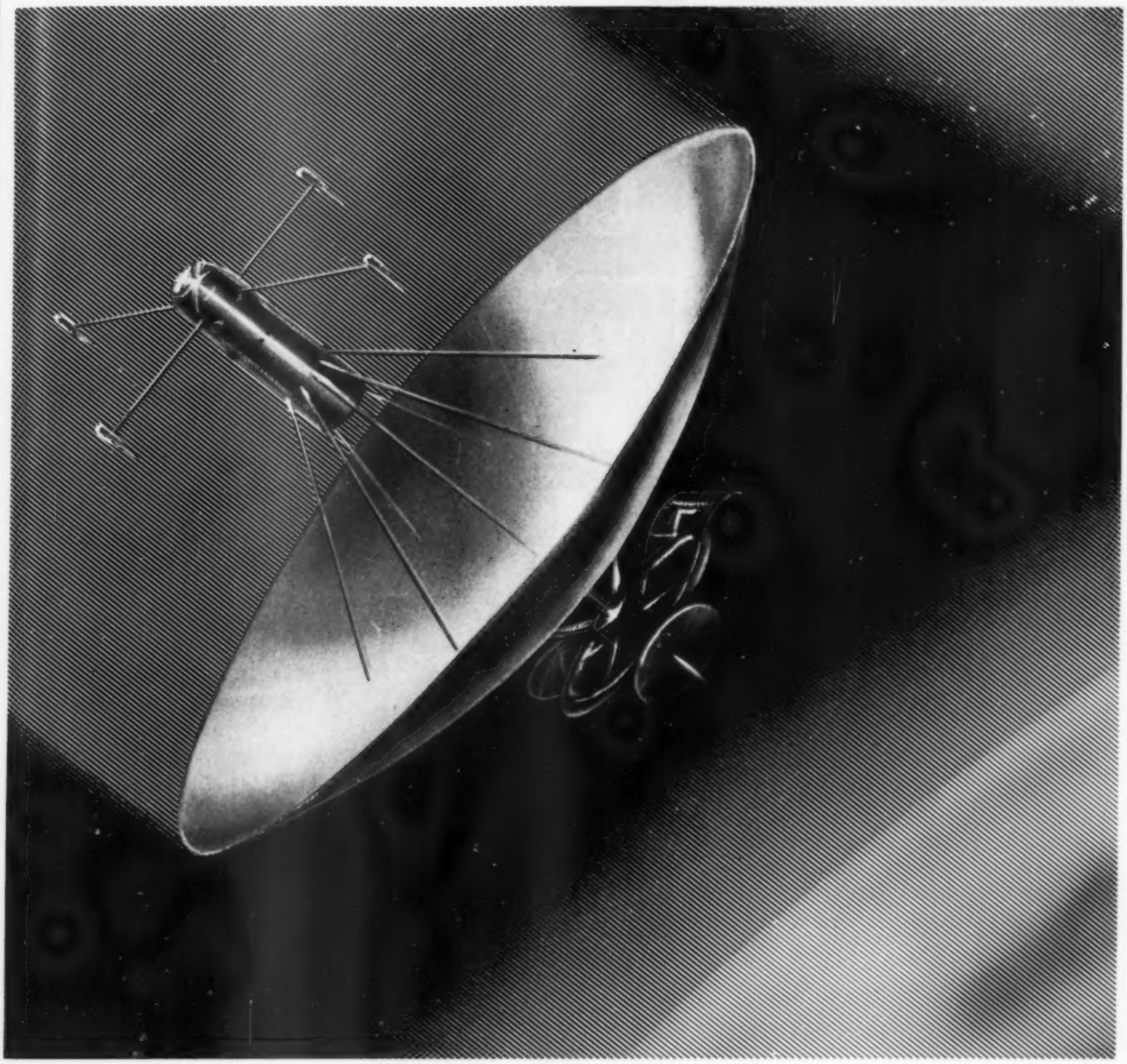

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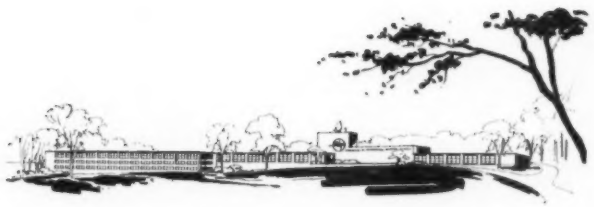

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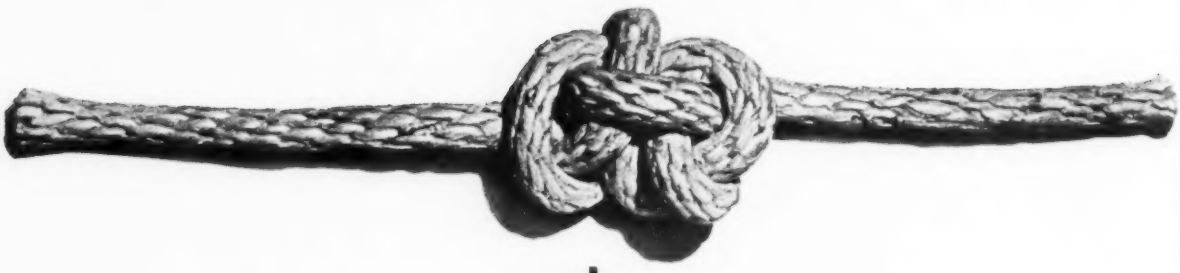

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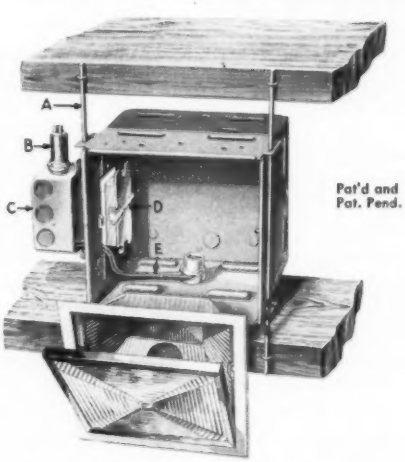

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Trend Of Affairs

The President's Report

THE ANNUAL REPORT of President Julius A. Stratton, '23, dealt with the many recent changes, current trends, and potentialities of M.I.T. in its second century. "In simplest terms," he wrote, "we propose to enhance the quality and character of professional education; to develop the physical environment of our campus so that it may contribute more effectively to the cultural and spiritual life of the student; and to create new facilities for furthering the advancement of scientific knowledge."

He cited as one of the extremely important steps taken lately "the development of teaching laboratories, new both in equipment and concept, which will supplement the new or revised courses in theory." He emphasized the great potential of interdepartmental laboratories and centers "in providing the desired balance and fullness of experience to the professional education of the engineer." And he called attention to some of the recent physical changes in the Institute:

- The Department of Aeronautics and Astronautics has given up the old student wind tunnel in Building 33 to provide a student projects laboratory.
- The Department of Mechanical Engineering has removed the majority of its materials-testing machines from Building 1, and some of its metal-cutting tools from Building 35, to provide space for more up-to-date equipment and studies.
- Senior House has become a self-contained unit by the addition of a gatehouse at the Ames Street end, and a wall and fence along Amherst Street.

Among other items in the report which are not reported elsewhere in The Review were:

- The student body last year numbered 6,270; enrollment in the Graduate School was 2,690.
- The Institute's academic expenses rose approximately 10 per cent to $25,468,000.
- Gifts during the year amounted to $17,355,000, as contrasted to slightly more than $10,000,000 in the preceding year.
- Thirty per cent of the undergraduates received scholarship aid; approximately 75 per cent registered for part-time employment.
- Seventy-one different countries were represented in the foreign student population of 739.

Copies of the report are being sent to all Alumni.

The Class of '64

THE 900 FRESHMEN who entered M.I.T. this fall came from 600 secondary schools in 45 states and 25 foreign countries. Eighty-four per cent were in the top tenth of their secondary school classes; 164 were valedictorians and 56 were salutatorians. Twenty-four, a record number, were women. Thirty-eight were children or grandchildren of M.I.T. Alumni.

(Three members of the new class are pictured above.)

In pre-admission interviews, the Class of 1964 expressed high interest in physics, nuclear engineering, and mathematics. But M.I.T. students tend increasingly, according to B. Alden Thresher, '20, Director of Admissions, to defer their choice of a major field of interest for a year or two, and the Institute is encouraging this trend.

Before regular classes began, the new class heard exhortations and encouraging remarks by President Julius A. Stratton, '23, and lectures on "The Accents of Cultures," by Professor Huston C. Smith; "Can Machines Learn to Think?" by Professor Philip M. Morse; "The Architecture of Solids," by Professor John Wulff; "Information Systems in Civil Engineering," by Professor Charles L. Miller, '51; and "Plasmas Open New Engineering Vistas," by Professor Herbert H. Woodson, '51.

They also heard Jonathan W. Bulkley, '61, describe his summer in Ghana as one of 190 American and Canadian students who took part in the Crossroads Africa project. Mr. Bulkley pointed out that a young Ghanian might become either a witchcraft practitioner or an airplane pilot; and his summer in Africa, he emphasized, had heightened his appreciation of his opportunities at the Institute.

Inertial Navigation Patents

TWO PATENTS covering significant advances in the art of inertial navigation of ships and airplanes were issued this fall to Walter Wrigley, '34, Forrest E. Houston, '48, and Joseph E. DeLisle of the M.I.T. Instrumentation Laboratory. Concepts and techniques covered by these patents already are being used in SINS (Ship's Inertial Navigation Systems) aboard missile-launching nuclear submarines, and may be applicable in commercial maritime and aviation industries.

709 Replaces 704

THE IBM 704 computer in the M.I.T. Computation Center, which 2,000 representatives of 32 New England schools have used, was replaced this summer by a $2,500,000 IBM 709. This new machine can be operated more efficiently, and Professor Philip M. Morse, Director of the Center, expects that by next year "the majority of the students entering M.I.T. will learn how to use a digital computer before they obtain their undergraduate or graduate degrees."

The International Business Machines Corporation contributed the 709, as it did the 704, as part of its program of assistance to education and academic research. The company also makes about 24 research assistantship grants each year, about half of which come to M.I.T. and half to other co-operating institutions. Only one other university has an IBM 709 devoted to education and research.

More than 1,000 different problems were run on the 704 during the three years it was at M.I.T. It calculated the orbit of Sputnik I, and worked on a great variety of other problems in accounting, nuclear physics, psychology, meteorology, business cycle prediction, physiology, astronomy, public medicine, and game playing. With it, too, M.I.T. researchers devised new "languages" to employ in communicating with computers. These included one called COMIT, used for machine translation and research regarding human languages; LISP (for list processor), which permits operators to instruct a machine to solve problems in mathematical logic; and DYNAMO, a language used in the simulation of industrial and business situations.

At the same time that Professor Morse announced the installation of the new machine, he announced the appointment of Fernando J. Corbato, '56, as Associate Director of the Computation Center.

Changes in Course VI-A

J. FRANCIS REINTJES, Associate Professor of Electrical Engineering, has become administrator of the cooperative course in electrical engineering at M.I.T., requirements for admission to the course have been modified, and more Faculty participation in the program has been arranged. Known as Course VI-A, this program permits undergraduates in electrical engineering to combine their academic studies with employment for specified periods in industry or government, and thus to gain an understanding of the bearing of scientific and engineering principles that are discussed in their classrooms on current engineering problems. The students in the program are selected by concerns co-operating with the Institute, and continue academic studies during their absence from M.I.T. All second-year electrical engineering students who are in good standing may apply for admission to Course VI-A now.

As its administrator, Professor Reintjes succeeds Eugene W. Boehne, '28, who has joined the engineering staff of the I-T-E Circuit Breaker Company, in Philadelphia, after heading Course VI-A for 13 years. Professor Reintjes has been a member of the Institute's Faculty since 1947, and is also Director of the Electronic Systems Laboratory.

Industrial and governmental organizations currently participating in the co-operative program, and members of the Faculty responsible for liaison with them, are: Air Force Cambridge Research Center (Bedford, Mass.), Lan J. Chu, '35; American Electric Power Service Corporation (New York) and Boston Edison Company (Boston), Karl L. Wildes, '22; Bell Telephone Laboratories (Murray Hill, N. J.), Claude E. Shannon, '40; General Electric Company (Pittsfield, Mass.), Robert L. Kyhl, '47; General Electric Company and Philco Corporation (Philadelphia), Henry J. Zimmermann, '42; General Electric Company (Syracuse and Utica, N.Y.), Leonard A. Gould, '48; General Radio Company (Concord, Mass.), Truman S. Gray, '29; International Business Machines Corporation (Poughkeepsie, N. Y.), Dean N. Arden; Raytheon Company (Waltham, Mass.), William M. Siebert, '46, and Louis D. Smullin, '39; and U. S. Naval Ordnance Laboratory (White Oak, Md.), Herbert H. Woodson, '51.

The changes made recently, to strengthen and expand the program, were recommended by a committee of administrators and alumni of the course which included Professors Woodson, Samuel H. Caldwell, '25; Marcy Eager; and Amar G. Bose, '51.

Automata in Russia

CONCENTRATION on the theory and applications of automatic control is a cornerstone of the Soviet Union's campaign to outdo the American economy, according to experts who attended the first congress in Moscow of the International Federation for Automatic Control last summer. It was a congress at which M.I.T.'s Faculty and Alumni were well represented, and a report on it was a highlight of a Joint Automatic Control Conference, sponsored by five professional societies, at M.I.T. this fall.

"They are vastly more aware of what we are doing than we are of their work," said John G. Truxal, '47, Head of the Electrical Engineering Department at the Polytechnic Institute of Brooklyn. The Russians place a heavy emphasis on control theory, but a move now under way to set up automation institutes for specific industries is calculated to marry theory to practice in the next five or ten years, other participants in the discussion agreed. "Russia is trying to leap-frog over 50 years of U.S. technical development which necessitated the development of great skill on the part of individual workers here," Dean Gordon S. Brown, '31, of the M.I.T. School of Engineering, pointed out. Automatic control has become a sacred cow there, he continued, because it is needed badly if they are, as they claim, to overtake the U.S. The point for us to realize, he concluded, is that the Soviets can play havoc with the orderly economic system of the free world if they want to, because by their totalitarian system they can set prices on goods that have the desired political effect, regardless of the cost.

The Shakespearean Imagination

EVERY Tuesday evening at 7:30 P.M., now, Norman N. Holland, '47, Assistant Professor of English at M.I.T., can be seen on WGBH-TV Channel 2 in and near Boston. He is giving a course entitled "The Shakespearean Imagination" for the Commission on Extension Courses of Harvard University. Professor Holland was formerly this educational station's "Film Critic." He is lecturing this year on 13 Shakespearean plays.

Freeing Children From Hunger

MANY CHILDREN in underdeveloped areas suffer from protein malnutrition. In the Indian village of Palin, Guatemala, parents recently were enabled to buy a new kind of food which will reduce such starvation. From three cents worth of it, three glasses of a drink can be made, each containing the same quantity and quality of protein as a glass of milk.

It is called Incaparina because the Institute of Nutrition of Central America and Panama (INCAP) was responsible for its introduction. INCAP's director, Dr. Nevin S. Scrimshaw, will come to M.I.T. next summer to head the Department of Nutrition, Food Science, and Technology (described below).

Incaparina is a mixture of vegetables which can be made into an "atole," or thin gruel, by adding water and cooking for 15 minutes. It can be served hot or cold, and flavored to taste with sugar and cinnamon, vanilla, or anise. Soon after it went on sale in Palin—a village of 4,500—1,200 bags a week were being consumed there. Arrangements since have been made for its production and sale in El Salvador, Honduras, Nicaragua, and some parts of the United States. Secretary of State Christian Herter has hailed its development as a "major breakthrough."

Dr. Scrimshaw described it during the International Congress on Nutrition in Washington this fall, and declared: "It is certain that products similar to Incaparina can be developed in other areas by taking advantage of those local food sources most readily available at low cost."

M.I.T.'s New Food Program

AS PART of the broad development of life sciences at M.I.T., the Department of Food Technology is being reorganized and will be known henceforth as the Department of Nutrition, Food Science, and Technology. More emphasis will be placed on the basic science and biological aspects of nutrition, and the Department will offer greatly extended curricula and research activities.

Samuel A. Goldblith, '40, the Department's Acting Head since the death of Professor Bernard E. Proctor, '23, will be its executive officer. Starting next August 1, its head will be Dr. Nevin S. Scrimshaw. He will continue an association with the Institute of Nutrition of Central America and Panama, and Institute students will benefit from close co-operation between M.I.T. and this international agency, which has a far-reaching program.

Now 42 years old, Dr. Scrimshaw is also a regional adviser of the Pan American Health Organization, the Regional Office for the Americas of the World Health Organization; an adjunct professor of public health in Columbia University; and a visiting lecturer in the Harvard School of Public Health. He holds the degrees of master of arts and doctor in zoology, doctor of medicine, and master of public health. He has studied a wide range of problems, including the physiology of development, vitamin assays and metabolism, nutritional factors in pregnancy, endemic goiter, protein and amino acid metabolism, nutrition and infection, and other aspects of clinical and public health nutrition. He

Dr. Nevin S. Scrimshaw is coming from Guatemala to participate in M.I.T.'s development of the life sciences.

received the Meade-Johnson Award of the Rochester Medical Society in recognition of his research on toxemia in pregnancy, is a member of many learned societies, and an honorary member of the Pediatric Society of Guatemala.

Dr. Scrimshaw and his family have made their home in Guatemala City for the last five years, but his recent work has involved him extensively in world as well as regional nutrition problems. In addition to studying protein and amino acid requirements, he has been involved in studies of disease and environment, how the body's use of fat is affected by diet, and how these factors in turn influence cardiovascular disease.

The department that he will head at M.I.T. has had a wide influence on the American food industry and the eating habits of the nation. It will continue its work in food technology and also emphasize food science and basic research oriented toward problems of human nutrition. In describing the change, Dean George R. Harrison of the School of Science called it "fairly radical" because it means "both an extension into new fields and strengthening of the food technology program in the direction of more basic research, particularly in the area of food toxicology and the effect of food processing on its nutritive value."

Robert S. Harris, '28, Professor of Biochemistry of Nutrition, participated in the meeting of Central Americans which led to the establishment of INCAP, and suggested at that time a co-operative arrangement with M.I.T. such as is now planned. "I hope it will be possible," says Dr. Scrimshaw, "for selected students to do Ph.D. thesis work at INCAP, and for physicians to receive training and experience in clinical nutrition, public health nutrition, and the appraisal of nutritional states in summer courses at INCAP."

Civil Engineering's Future

MAJOR CHANGES were made in the undergraduate Civil Engineering (Course I) program at M.I.T. this fall. While maintaining the strength of portions of the previous program, the new curriculum nevertheless represents an appreciable modification of the classical images of civil engineering, reflecting the trend to devise new courses that will meet the demands of the future and take advantage of the special characteristics and capabilities of M.I.T. students.

Modern physics, thermodynamics, fluid dynamics, electrical engineering, particulate mechanics (the study of particles such as those in the soils), and materials engineering are among the subjects now offered. Additional requirements include statistical theory and mathematical methods in civil engineering, including operations research and computer methods.

The Department of Civil Engineering also has developed subjects in co-operation with other departments covering such fields as geotechnical science and biological, social, and political factors in engineering.

The student still takes subjects such as structural analysis and design, hydraulic engineering, and transportation engineering as part of his program, but with the broadened base in science and mathematics there is less emphasis on professional specialization.

In making these changes, the Institute's Faculty is looking to future trends. (See "Civil Engineering's Scope Now," by John B. Wilbur, '26, on page 31.)

The 10-to-the-10th Event

A FAR GREATER cosmic-ray shower than ever was detected before fell last December on the Laboratory for Nuclear Science's Volcano Ranch Research Station near Albuquerque, N.M. It was described, when announced last summer, as a 10-to-the-10th event, because 10 billion particles rained down on the station's counters. It was three times as intense as the record shower caught by the tubs set out at the Harvard Agassiz Observatory in 1957.

Calculations showed that the energy of the cosmic ray that caused the great shower to fall in 10 millionths of a second must have been between 20 and 40 billion billion electron volts. This is at least 500 million times the highest energy imparted to a particle in a man-made atom smasher.

Bruno B. Rossi, Professor of Physics, is convinced of the extragalactic acceleration mechanism for cosmic rays as a result of this and other recent discoveries. Now one of the most pressing questions facing the cosmic-ray physicists, says Stanislaw Olbert, '53, Assistant Professor of Physics, is the nature of the cosmic-ray particles. It has been assumed that most of the primary rays are protons, but ionized nuclei of heavier elements may be more abundant than has been thought.

John Linsley and Livio Scarsi reported the big shower. Their work was part of a broad research program supported by the National Science Foundation.

Who Tells Who Over There

How is scientific and technical information disseminated in the Soviet Union? Since the system of exchanging information there was developed under different circumstances than have prevailed here, a study of it may reveal different approaches and solutions to problems that confront researchers everywhere. To learn more about it, the National Science Foundation has arranged for a comprehensive, two-year, M.I.T. study of the Soviet system. Boris I. Gorokhoff, formerly of the Library of Congress, is joining the Institute staff to devote himself to this investigation.

The nature, purpose, organization, and financing of information dissemination in the U.S.S.R. will be examined. The study also will cover recent major changes, and the newly formed Council for Cybernetics and its activities.

A DYNAMIC TESTING device for auto suspensions interested Douglas P. Adams (left), Associate Professor of Engineering Graphics, during a General Motors conference at its technical center for engineering and science educators. C. Elbert Valentine, 3d, '57, of the GM engineering staff, discussed its operation with his guest from M.I.T.

HEADED FOR NIGERIA, William L. Hooper, '57, was briefed by Dean Howard W. Johnson (left) and Carroll L. Wilson, '32, of the School of Industrial Management. Mr. Hooper is one of eight recent M.I.T. graduates now on two-year tours of duty in Africa under a program for providing assistance in the development of new countries.

Useful Belts in the Sky

WALTER E. MORROW, JR., '49, of M.I.T. Lincoln Laboratory described a new and novel global communication system at this fall's meeting of the International Scientific Radio Union in London. Known as "orbital scatter," it would utilize the reflective properties of thin belts of metallic fibers (or dipoles) sown in the sky at an altitude of several thousand miles.

These fibers could be only about half an inch long and one-third the diameter of a human hair. They could be so strewn out that the average distance between fibers would be a thousand feet. Yet men could communicate by radio between distant points on the earth's surface by training their transmitting and receiving antennas on such a belt. A great many exclusive communication circuits could operate simultaneously. And two such belts—one orbiting above the equator and the other over the North and South Poles —would make continuous communication possible between any two points on earth.

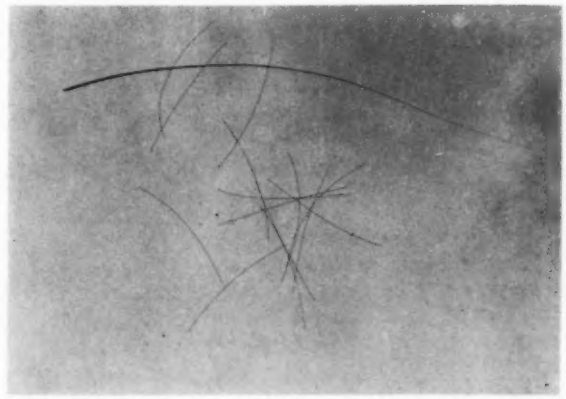
A belt could be established, it is believed, by gradually releasing millions of fibers from a container ejected from a rocket in the desired orbit. The belt could be so designed that its lifetime would be a matter of months or years. It would not be affected greatly by solar radiation pressure, atmospheric friction, magnetic fields, micro-meteorites, or high-energy particles. Nor would it interfere seriously, those who have suggested it say, with astronomical observations or the use of space for other purposes.

Tuned to resonate at radio frequencies near eight kilomegacycles (8,000 million cycles per second), the "dipole" fibers resemble the familiar dipole antennas used for TV and FM reception. At these frequencies, they scatter radio waves so efficiently that only nine ounces of copper dipoles (with a projected area of less than 20 square feet) would produce as strong an echo as the 100-foot-diameter space balloon Echo I, which has a projected area of almost 8,000 square feet. The balloon, on the other hand, reflects equally well over a very wide range of radio frequencies, but is relatively difficult to track with large antennas as it speeds across the sky.

Since the belts would be relatively stationary in space, no high-speed tracking equipment would be needed to keep radio antennas trained on them. And since all of the active radio equipment would be on the ground, the communication system envisioned could be highly reliable.

Mr. Morrow developed the basic concept in collaboration with Harold Meyer of the Thompson-Ramo-Wooldridge Corporation. Lincoln Laboratory now is preparing experiments to test the feasibility of the technique and confirm the results of theoretical studies.

Two "orbital scatter" belts of tiny metallic fibers in sky could relay radio messages over very long distances.



A cat's whisker (at top) about two inches long would dwarf the fibers sown in the sky for such a communication system.

Pressure on Echo I

AT AN ALTITUDE of 1,000 miles, 10 cubic miles of air weighs only about as much as one cubic inch at sea level. While a few men were bouncing signals off Echo I, and most of us were just admiring it, last summer, others sought accurate values of the air's density up there and looked for the effects of solar radiation pressure. Their orbit measurements confirmed a theory concerning the impact of solar pressure which had been advanced by Harrison M. Jones and Irwin I. Shapiro of M.I.T.'s Lincoln Laboratory and R. W. Parkinson of the Thompson Ramo-Wooldridge Corporation.

The total force of solar radiation on the balloon is quite small—estimated to be about equal to the weight of a salted peanut—but the balloon is so light that the effect on its orbit is quite dramatic. The altitude at perigee—the point of closest approach to earth—was observed to decrease by more than 27 miles during the first 12 days after launch, strictly in accordance with the theory, which further predicted that the decrease would continue for about five months and a total decrease of 400 miles in perigee altitude, if the balloon remained reasonably intact. The altitude should then begin to increase again, and continue to oscillate over a 400-mile range for several years to come.

The ability to predict the effect of solar pressures on large, lightweight satellites will clearly be helpful in determining the optimum orbits and launching times for specific missions.

Second Century Fund's Leaders See M.I.T.'s Expanding Needs

Faculty and Alumni emphasize educational excellence and service to the nation in explaining the program to increase the capital funds

EDUCATION IS "at the heart" of M.I.T.'s Second Century Fund, John J. Wilson, '29, its general chairman, declared at the Fund's Leadership Conference, September 9 and 10 in Cambridge—and this was the tenor of the whole two-day meeting. More than 200 Alumni and friends of the Institute, representing 55 classes and 29 states, met to hear talks by Alfred P. Sloan, Jr., '95, the Fund's Honorary Chairman; James R. Killian, Jr., '26, Chairman of the M.I.T. Corporation; President Julius A. Stratton, '23; and many other spokesmen for the Faculty and Fund.

"Successful achievement of any kind guarantees expanding needs," President Stratton declared in opening the conference. The 66 million dollars that the Institute is seeking, he emphasized, will be used not to enlarge M.I.T., but to enable it to continue to meet the needs of the times and the country.

"The Institute," said Dr. Killian, "is making up for lost time." During the war, its people devoted themselves unstintingly to the war effort. In the quarter century prior to 1949, the Institute made no substantial effort to augment its capital funds save for small amounts to build a dormitory and a swimming pool. "The result is," Dr. Killian pointed out, "that today we find the Institute is inadequately capitalized to carry its present program and to take care of improvements."

A further reason for seeking capital funds now, he continued, is the rapid and, in fact, desirable obsolescence of its plant, equipment, and programs. By its own action, if it is successful, an institution such as M.I.T. creates change and new knowledge, which produces new obsolescence.

In the Laboratory for Nuclear Science, experiments in space and the apparatus built to perform them intrigued Alumni visitors.

"From its beginning," he recalled, "M.I.T. has been the embodiment of a new ideal in education. M.I.T. has always possessed within itself the seeds of further strength, and it has steadily proved itself by serving the nation well. And so today, its surging intellectual vitality, its momentum, and its latent capacity for further greatness are at new highs. With this kind of institution, and with its superbly creative Faculty and student body, we may expect it always to be providing ample justification for additional resources."

Teaching and Research

Gordon S. Brown, '31, Dean of the School of Engineering, declared that the Institute's strength lay in the interplay of research, undergraduate courses, and graduate work. "We are convinced," he said, "that the

William E. Barbour, Jr., '33, and Patrick D. Wall on biology tour.

Richard H. Catlett, '17, speaking to Fund Chairman John J. Wilson, '29.

Frederick H. Dierks, '12, and Louis J. Darmstadt, '26, at the dinner.

Mrs. Robert C. Dean, '29, and Dorothy W. Weeks, '23, examining a model.

William H. Coburn, '11, and Norman I. Sebell, '44, listen to Professor Irwin W. Sizer describe electrodes used to study cells.

effective pursuit of new and emerging areas can best be carried on through the development of Centers, where staffs from many departments can intermingle."

C. Stark Draper, '26, Head of the Department of Aeronautics and Astronautics, described the ways in which his Department endeavors to make the most effective use "of each heartbeat of the student and instructor." Its faculty, he declared, is "quite closely coupled to the environment," and the Instrumentation Laboratory not only has contributed greatly to the nation's strength by its research but has made "the internship type of teaching" available.

Irwin W. Sizer, Head of the Department of Biology, reviewed the last two decades of growth in interest in the study of living organisms on the molecular level, and showed impressive pictures and models of biological molecules. William P. Allis, '23, Professor of Physics, told a similar story of increased interest and progress in the study of plasma physics. *(See page 27.)*

John T. Rule, '21, Dean of Students, introduced Joseph Harrington, 3d, '61, and Douglas A. East, '55. Mr. Harrington described his work in economics and nuclear engineering, and emphasized the diversity of M.I.T. undergraduates' interests. Mr. East told how, as a graduate student and instructor, one "works

(Concluded on page 54)

A Duty to M.I.T. and Society

IN AN ADDRESS *to Second Century Fund leaders, at their meeting in Cambridge on September 9, Alfred P. Sloan, Jr., '95, their honorary chairman, spoke as follows regarding the Institute:*

WE, THE ALUMNI, in promoting the interests of the Institute, should look upon our doing so not only as an obligation to a great scientific and educational cause but as a partial payment of the debt we owe the Institute for services rendered to us, as undergraduates, enabling us to qualify for the opportunities and obligations of the world in which we live. There is no greater responsibility than to pay one's debts.

M.I.T. has passed through various phases in the evolution of years. When I was an undergraduate, Technology ranked as little more than a leading engineering school. Inspired by the imagination, the talents, and the leadership of the late Karl T. Compton, Technology emerged from the status of an engineering school into a great scientific institution, thus enormously enhancing its responsibilities for service to our society, not only in the area of education but in all the various areas of scientific research. The Alumni, as I see it, owe and should recognize a deep obligation to the memory of the late Dr. Compton, by not only making it possible to strengthen the scientific concept conceived by him but to erect on that foundation a great superstructure of constantly expanding service in recognition of the changes of time.

It is well said, I believe, that in our system of private enterprise—and I do not know that education is any different—most components are available to all who can qualify. The great differences between mediocrity and a high level of accomplishment are the people involved, their leadership, and how they work together.

Since I was relieved from the confines of General Motors, and have had an opportunity to look around, especially in the area of education, I am constantly impressed with the broadly accepted recognition of Technology as the leading technological institution, not only in this country but in the world at large. That fact stands out crystal clear. *It may be difficult—as a matter of fact, it is difficult—to reach the top, but it is far more difficult to stay there than to get there.* Hence, we get back to the significance in any type of human effort of the people involved, their leadership, and how they work together.

Certainly we, the Alumni, would be derelict in our duty to the Institute and to our society, to say nothing of ignoring our opportunities, if we failed to appreciate our outstanding leadership and the competence of that leadership and to rally our loyalty, our confidence, and our maximum effort to the support of Dr. Killian, Dr. Stratton, and their able group of scientists and educators, by providing the essential ways and means, or the tools, to capitalize the talents thus available to us and to utilize the expanding opportunities for service that continually present themselves. . . .

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Our world is in a state of unstable equilibrium—in a mess, perhaps better describes it. Grave danger lurks in many areas. It appears that the decade of the '60's may well be the most critical period of the Twentieth Century. The prime question before the world's leadership is: What must be done about it? Undoubtedly, military power is a deterrent against physical attack; more militant leadership may help; financial aid to less advanced countries perhaps offers a worth-while piece of expediency; and the encouragement of more social, educational, and creative interchanges between peoples, made feasible by advanced means of transportation, offers, I believe, the promise of something worth while. But, is it not true that in the final analysis the basic cause for the world's unrest, and the danger that exists today, in a climate of apparent prosperity, is lack of knowledge, or ignorance, expressing itself in far too many areas in appallingly low standards of living and appallingly high levels of political incompetence, dominated by ignorance and selfishness? How can the world's free institutions be expanded and strengthened in such a background?

It may be academic to say that knowledge is the means of promoting progress and security along the whole front of human endeavor. It is a fact nevertheless. Social values, economic values, scientific values, human values involving human behavior—political and moral, health, security and spiritual values—all have their roots in knowledge and can thrive only in an atmosphere of expanding knowledge and understanding. And is it not true that education is the catalyst, or creative intrumentality, upon which the expansion of knowledge depends? *Education could be the significant factor in the survival of our existing civilization.* Does not such a concept, looking over our immediate horizon into the great beyond, broaden our responsibilities to the Second Century Fund?

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The goal of the Second Century Fund is an ambitious one. I am quite convinced that it has been most thoughtfully developed. Each component part might be looked upon as a building block in an imaginative vista of a great superstructure of constantly expanding service based upon a broad and solid foundation of scientific and educational accomplishment. Each such building block is an essential part of a co-ordinated and balanced whole. *To obtain our objective will not be easy. It will require hard and aggressive work. But it can be done.*

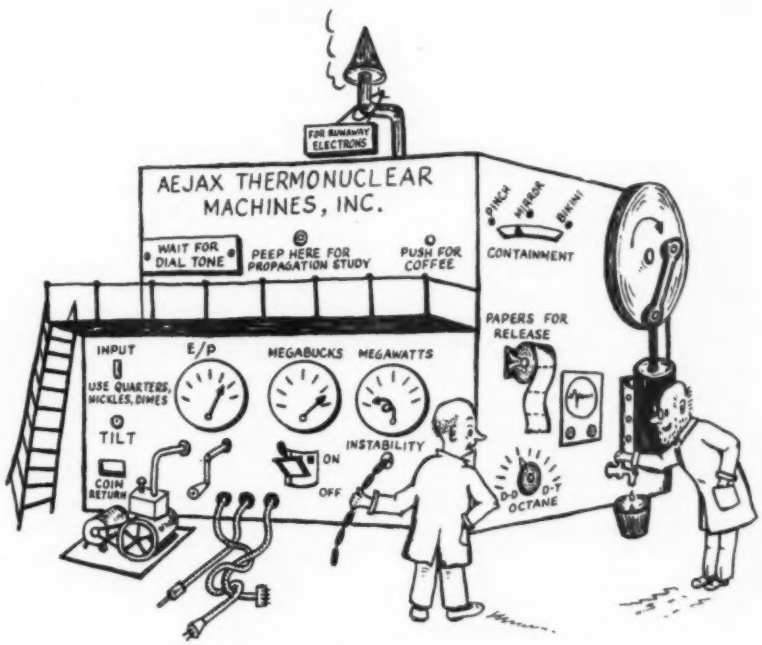
Plasma Research: A Case History

The men who spend "big money" for Uncle Sam now were trained when support was meager and only "fuddy-duddies" really cared

PROFESSOR WILLIAM P. ALLIS, '23, *candidly summarized the history of plasma physics for M.I.T. Second Century Fund leaders at their meeting in Cambridge this fall. Plasmas are ionized gases, consisting partly of neutral atoms and partly of atoms from which an electron has been removed. Professor Allis' account of this wonderland follows:*

THE ORIGINATOR of plasma physics in this country was Irving Langmuir, some 30 years ago, whose interest in this field was stimulated by the importance of mercury rectifiers. His successor in this field was Karl T. Compton, who was later deflected into administrative work. My interest originated from my postgraduate work on atomic cross sections with Arnold Sommerfeld in 1930 and continued because the new-fangled quantum theory was too difficult for me. I struggled rather vainly with Boltzmann theory until 1941 when Sanborn C. Brown, '44, a student of Robley D. Evans, came to me with a stack of data on Geiger-Müller counters and asked for help in developing a theory for them. This started a fruitful collaboration of theorist and experimenter.

World War II interrupted our work, but then supplied a vital element: We fell heirs to the microwave equipment and techniques of the Radiation Laboratory, and this directed our efforts into microwave discharges. A fourth element, money for research assistantships, was supplied by the armed services through the Research Laboratory of Electronics. These four elements plus the students constituted "a plasma school" of about 12 people with a budget of $60,000. This was then practically the only "plasma school" in the country, the one at the University of California under Leonard Loeb being relatively small.



"Well, at least we got the water back."

Basic plasma research is seldom photogenic. Professor David J. Rose, '50, of M.I.T., drew this cartoon for colleagues studying thermonuclear reactions.

We have trained some 30 Ph.D.'s, the most prominent among whom is Benjamin Lax, '49, the Director of our new Magnet Laboratory which is being erected on Vassar Street. He was one of the first to study the effects of a magnetic field on a plasma. The recent explosive growth of interest in plasmas is entirely connected with their interactions with strong magnetic fields.

In 1952 the possibility of controlling a thermonuclear reaction in a magnetic bottle was glimpsed, and the Atomic Energy Commission embarked on a gigantic effort to beat the Russians in doing so. Both sides lost in this contest. M.I.T. voluntarily refrained from participating in this effort at first because of the security restrictions, but now that the security has been relaxed we have an A.E.C. contract of $250,000 which supports about 30 people. It is unclassified and of great educational value. With it we do much of the truly basic research for the A.E.C. The thermonuclear research budget of the A.E.C. amounted in 1959 to $27,000,000, the largest contracts being with Princeton, the University of California, and Union Carbide, for research with colossal machines in laboratories off-campus which, therefore, have little educational value. Only 1 per cent of this budget goes to education.

In the meantime the universal importance of plasmas was being "discovered":

¶ The small magnetic fields in *interstellar space,* because of their

great extent and because of the conducting plasma between the stars, were found to be strong enough to pull the stars into the spiral arms of the galaxies, and to accelerate cosmic rays.

¶ Probing satellites discovered belts of plasma, the *Van Allen layers*, around the earth.

¶ *Re-entering missiles* generated plasmas in the atmosphere hot enough to melt their nose cones.

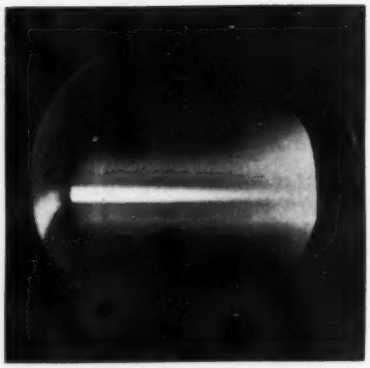
¶ The *exhaust jets* of rockets are themselves plasmas and worthy of study.

¶ The *plasma jet* was developed as a high-temperature environment (15,000 degrees C.) for the study of materials.

¶ *Magnetohydrodynamics,* which is the science of pushing conducting fluids around with magnetic fields, showed promise of using plasmas dynamically to convert energy between its electrical and mechanical forms, and thus possibly do away with rotating electrical machinery.

¶ The *plasma diode* is a device which converts thermal energy directly into electrical energy and may very soon be practical.

The funds available to the Electrical, Mechanical, and Nuclear Engineering Departments were quite inadequate for them to enter these promising new fields. They also wished to share know-how and facilities with those already existing in the Physics Department. To this end, funds were sought and a grant of $500,000 for two years was obtained from the National Science Foundation. This is the largest single grant of its kind that the foundation has made, and differs from our other funds in the freedom which we have in using it. We hope that our results will be such as to encourage the National Science Foundation to expand this policy of granting funds to develop research in an area of science.



You are looking into a vacuum chamber, at a simple, highly ionized gas. An inexpensive way to produce such a plasma, containing hardly any neutral particles, has been found by Professor David J. Rose, '50, and members of the Thermonuclear Division of the Oak Ridge National Laboratory. It is being developed both at Oak Ridge and at M.I.T. as a research tool.

The gas is fed into the chamber through a cathode within a magnetic field. While still inside the cathode, the gas becomes almost fully ionized; when it leaves, the interactions between its particles are nearly all electrical. With this plasma stream, wave propagation, electrical noise, and oscillations can be studied in new ways.

An interdepartmental committee was set up to co-ordinate the work in the Electrical, Mechanical, and Nuclear Engineering and Physics Departments, and the business office of the Research Laboratory of Electronics takes care of all administrative problems. We now have about 100 people working in this area, of whom 12 are professors, and a yearly budget from all sources of $700,000. Departmental lines are so nearly erased in the research work that I hardly know which department any of my students belongs to.

In due time we will have close links—probably copper bus-bars—with the new Magnet Laboratory. Our requirements are somewhat different from those for solid-state research as we need smaller fields over larger volumes, but the current requirements are the same. Our most urgent requirement, however, is for a common roof under which we may work together.

The moral of this story is that the development curve for a research effort in any field has a long approach followed by a steep front and a slow decay. Government or other funds are generally available for the steep front, when the need is obvious, although even then most of the money goes into nonbasic research, and 1 per cent to education. But the long approach has to be done by the universities on their own funds, because the men who do this are "the fuddy-duddies who don't see what is important." Yet this is when the people are trained who will spend the big money later.

Pertinent Facts About M.I.T.

M.I.T. probably has the most comprehensive and varied research program in the physical sciences and technology to be found in any one place in the world. It has currently under way 900 separate research projects.

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M.I.T. awards 13 per cent of the nation's total output of doctorates in engineering and 10 per cent of all master's degrees in engineering. The number of engineering doctorates awarded by the Institute is more than double the number awarded by the second-ranking institution.

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The Institute currently awards over 8 per cent of all U.S. doctorates in physics, and on no other single campus in the United States have so many doctorates in physics been awarded.

Harvard and M.I.T. stand first and second, respectively, and far ahead of most other institutions, in the number of National Merit Scholarship recipients enrolled.

M.I.T. virtually created the modern profession of chemical engineering and was the first technological institution to recognize and provide for economics as an important element in the education of the engineer. The Institute was the first school to establish courses in aeronautical engineering, architectural engineering, chemical engineering, food technology, industrial biology, marine engineering, and naval architecture.

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Some 1,500 M.I.T. Alumni are presidents of private companies and institutions in the United States; about 1,200 are vice-presidents.

The Greatest Magnets of All Will Be at M.I.T.

Prof. Francis Bitter will direct the building of the new magnets.

THE CLASS OF 1964 at M.I.T. will watch as undergraduates the construction of a new national center for the study of magnetic phenomena. During the next four years, the apparatus needed to produce a continuous magnetic field of unprecedented strength will be assembled at M.I.T. Construction of a new laboratory to house it is scheduled to begin next year. When completed this laboratory will be the world's most advanced facility of its kind for research regarding properties of matter and energy.

This will be the next leg of the "voyage of exploration" on which Professor Francis Bitter embarked more than a quarter of a century ago. In the 1930's he developed solenoid magnets, operated by a 1.7-million-watt power station, capable of sustaining a field of 100,000 gauss. These still rank among the world's great magnets, but those now being designed will be far more powerful. They will produce a continuous field of 250,000 gauss. This is 500,000 times the strength of the earth's magnetic field.

Professor Bitter has given up his position as Associate Dean of the School of Science to assume primary responsibility for the design and completion of this facility. Since its program will be focused on earth and space science, as well as on electronics and atomic physics, he will be professor of geophysics henceforth rather than professor of physics.

Benjamin Lax, '49, will be the new laboratory's director, and Donald T. Stevenson, '50, will be its assistant director. Henry H. Kolm, '50, and D. Bruce Montgomery, '56, are designing the magnet and participating in the planning of the laboratory. All four members of this team are associated with Lincoln Laboratory, Dr. Lax as head of the Division of Solid State Physics, and Dr. Stevenson as a group leader in this division.

Dr. Lax, whose special field is the study of electrical properties of semiconductors, received the Oliver E. Buckley Solid State Prize of the American Physical Society this year. His research in the fields of cyclotron resonance in semiconductors, magneto-optic properties of solids, and the electromagnetic behavior of ferrites, has provided new insights into the basic electrical structure of solids. This kind of basic understanding is a vital link in the development of practical solid-state devices such as transistors, masers, and ferrite microwave components.

James M. West, who was contract negotiator for Lincoln Laboratory before becoming associate director of the M.I.T. Division of Sponsored Research, will be assistant director for administration of the new laboratory.

Benjamin Lax, '49 (left), will be the laboratory's director; James M. West (center) and Donald T. Stevenson, '50, will assist him.

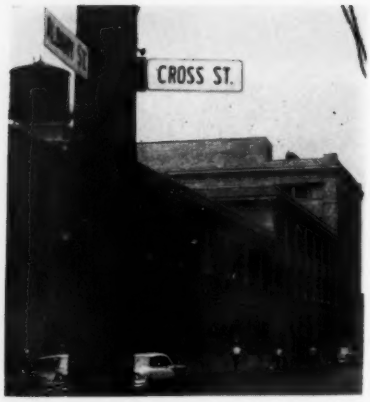
An Air Force Project

The Institute and the U.S. Air Force concluded a $9,502,000 contract several months ago for the construction of this laboratory. Plans for it were announced simultaneously by Lt. Gen. Bernard A. Schreiver, Commander of the Air Research and Development Command, and President Julius A. Stratton, '23.

The over-all cost of constructing the laboratory was estimated at $6,078,000 and $3,424,000 was allocated for staffing and preliminary research. Of the total, $5,600,000 was designated for construction and management during the fiscal year which began last July 1. The laboratory's annual research budget after it goes into full operation in 1964 is expected to be about $2,000,000.

The new laboratory will be alongside the Institute's nuclear reactor on Albany Street, on a site occupied for many years by the Ward Baking Company's building. Most of this building will be razed, and construction of the new facility will begin soon. A two-story structure adjacent to eight magnet test cells and the power supply is planned to accommodate supporting shops and offices.

Jackson and Moreland, Inc., of Boston, which worked with Profes-



The new magnet laboratory's site.

sor Bitter on the high-field magnet facility that he developed for M.I.T. many years ago, has prepared preliminary design studies, and is now furnishing engineering services.

Novel engineering solutions will be required both to provide the necessary power and to cool the magnets. An 8-million-watt power plant with an additional pulsed capacity of 32-million watts is planned. This plant will be capable of furnishing 40,000 amperes at 200 volts direct current on a continuous basis, and 160,000 amperes will be made available for two-second periods by using energy stored in large flywheels. The short-time, high-power operation will result in the production of extremely intense magnetic fields with more volume than those produced on a continuous basis. Because of the heat that will be generated, large amounts of high-purity cooling water will be needed. This will be cooled by water pumped to the site from the Charles River.

The Research Program

The impetus for creating this new laboratory came from the active scientific program in solid-state physics at Lincoln Laboratory.

Magnetic fields govern and can help explain much of the behavior of atoms, atomic particles, and aggregations of atoms in solids, liquids, and gases. Magnetic phenomena figure importantly in cosmological theories as well as in studies of atomic nuclei. Increased understanding of such phenomena could prove helpful in many sciences, and in the solution of such varied engineering problems as the exploitation of materials, the improvement of communications, and the development of new sources of energy.

In explaining the new laboratory's program to the press, Dr. Lax pointed out that electrons and atomic nuclei are like minuscule spinning tops, whose motion is strongly influenced by a magnetic field, just as the earth's gravity causes a toy top to wobble around its stable position. The higher the magnetic field one attains, the easier it becomes to measure with precision the interaction of these electronic and nuclear tops.

An electron in a magnetic field goes in circles at a frequency which increases with the strength of that field. For a given field, this frequency is often much higher when the electron is in a solid than when it is in a gas. This frequency, moreover, can change if the direction of the magnetic field relative to the crystalline axes is changed. By measuring these frequencies physicists have explained some of the complexities of a large variety of materials.

Higher magnetic fields are expected to be helpful in ascertaining further quantitative details of nuclear structures and acoustical and optical phenomena. They will make it possible to study a greater number of semiconductors and metallic alloys than have been examined thus far.

"The new laboratory," Dr. Lax said, "will foster activities that enrich our knowledge not only of solids but also of gases, liquids, and ionized gases, and undoubtedly will contribute to our eventual peaceful use of thermonuclear energy and to the development of new electronic devices."

New Biology Laboratories

THE INSTITUTE'S biology laboratories were enlarged this fall by a major change in the John Thompson Dorrance building. The greenhouse on its roof is gone, and its eighth floor is now the same size as those below it. The additional 2,900 square feet of laboratory space thus provided will be used mainly for research in embryology and tissue culture.

Eugene Bell, Associate Professor of Biology, will have an embryology laboratory at one end of the building, and James E. Darnell, Jr., Assistant Professor of Biology, will have a specialized tissue-culture laboratory at the other end. Dr. Bell is noted for his use of ultrasonic techniques to study the development of limbs. Dr. Darnell, who is now working at the Pasteur Institute in Paris, will come to M.I.T. next year. Here he will be associated with Professor Salvador E. Luria in the study of such problems as how viruses invade cells. Space left available by moving Dr. Bell's laboratory to the eighth floor will be used to enlarge Professor Patrick D. Wall's neurophysiological laboratory.

Molecular and cellular biology will be closely integrated in the new laboratories' research program. It will include studies of bacterial genetics, enzyme formation within cells, metabolism of cells in tissue culture, and other phenomena in living cells. Mammalian cells will be grown, the way bacteria and experimental animals have been, in controlled environments. Viruses are believed to figure in certain types of cancer, and this will be one of the possibilities explored. The opening of these laboratories, in fact, is the first stage of a long-range program planned to make the Institute one of the world's leading centers for the study of biology at microscopic and submicroscopic levels.

Building and equipping the new laboratories with air-conditioned, dust-free rooms, and the necessary sterilization, incubation, and other apparatus, has cost more than $240,000, of which $100,000 came from the National Institutes of Health. Anderson, Beckwith, and Haible were the architects; Severud, Elstad and Krueger, the Delbrook Engineering Company, and Edwin P. Mahard provided engineering services; and the Rich Construction Company, of Boston, was the contractor.

Civil Engineering's Scope Now

It fulfills human needs through adaptation and control of the land, water, and air environment

BY JOHN B. WILBUR

JOHN B. WILBUR, *'26, has headed the M.I.T. Department of Civil and Sanitary Engineering since 1946. As a participant in a Conference on Civil Engineering in Ann Arbor, Mich., last summer, he contributed the thoughts that are set forth in this article.*

WHAT is a civil engineer? We recoil in dismay when we sometimes find that the public thinks of us as men in muddy pants, peering through transits; for we, of course, know better: We know that a civil engineer is one who uses science "plus" to fling gleaming spans across chasms, to carve the countryside with interchanges and with super-highways, to change the very geography of the earth with mammoth dams, and to rear mighty structures skyward where they stand undaunted through earthquake and storm. We know that a civil engineer may be a structural engineer, a sanitary engineer, an hydraulic engineer, a soils engineer, a building engineer, or—you name it.

Is it possible that, without our having realized it, the civil engineer, as such, has become something of a figment of the imagination? Has civil engineering become, in effect, a general term that embraces a variety of areas such as structures, transportation, and waste disposal, each important in its own right, but with little to relate them in underlying unity of purpose?

We deal primarily with public works, you may say. Highways, bridges, water supply, sanitation, and similar undertakings are so close to the social and economic welfare of people that they are primarily associated with government. Public works, together with corresponding engineering for industry, reveal the nature of civil engineering. Here, indeed, is a plausible characterization of our profession; but something of importance, it seems to me, has been omitted. For public works are not ends in themselves, but are built to perform certain functions; and when we begin to enumerate these functions we are back to transportation, waste control, water supply, and shelter—and still faced with the atomistic purpose of our calling.

Or again, it may seem to some of us that "construction" is the key word of the civil engineer; everything that he plans and designs, it may be pointed out, has true meaning only when it is translated into reality. Here is another plausible characterization of civil engineering; but here again we find no unity of underlying purpose. To construct something is no more an end in itself than to design public works.

An Idlewild building photographed by F. S. Lincoln, '22.

If a young man is thinking of medicine, law, aeronautical engineering, or metallurgy as a career, an understanding of the underlying purpose of the field does not seem difficult to come by; but when we turn to civil engineering, this is more elusive. Unity of purpose in our field would not only help young people in their career decisions,. but would help us design educational programs; indeed, it would inject a greater spirit of unity and clearer identity of goal into the entire civil engineering profession. It somehow should be made apparent to everyone that the civil engineer in the laboratory who is studying the turbulence of water is working toward the same basic objective as the civil engineer in the design office who is determining the proper thickness of a concrete shell.

Radioactivity's Threat

I cannot very well point out the need of a unifying theme of purpose in civil engineering without offering a suggestion as to the form that it might take. There are trends that we should be guided by. Among these are today's rapid tempo of scientific and technological advance, the explosion of population, and the rate at which we are plundering our natural resources. Associated with all three of these trends is the rate at which man seems to be poisoning—and in some instances strangling—much of the environment in which he lives.

The pollution of lakes and streams with sewage and industrial wastes, for example, has long been one of the problems to which civil engineers have addressed themselves. Now we are faced with a newer and graver situation, arising from the increasing importance of radioactive by-products. Not only health, but life itself may

be at stake; the problem is pointed up when it is realized that by 1980, according to estimates, all the waters of the oceans will not be sufficient to dilute—within man's tolerance to radioactive substances—a single year's output of fission products.

Water, that essential of man's environment which frequently has been so plentiful that many of us have taken it for granted, is becoming a scarce commodity. It is estimated that by 1980 there will be 200 million people in the United States alone; three-quarters of this population will be living in industrial complexes extending continuously for several hundred miles along coastal waters and inland waterways. The quest for new sources of water to support these concentrations will be endless. We must find not only new sources but new methods of treating water—for it must be used and reused, and then used again.

Or let us turn to the air, so plentiful on clear days, yet so restricted at times that some of our metropolitan areas are faced with serious problems of smog. Hydrocarbons, which some believe to be cancer-producing, are being discharged into the atmosphere in tonnage quantities today, to say nothing of tomorrow. Methods must be found to control these airborne wastes.

Buildings and other structures not only control man's environment, but are part of that environment. I believe that we have gone too far in building structures "for the ages," so to speak—for permanence in structures, while sometimes desirable, is basically the equivalent of a long-term commitment to the shape of the world around us. Today, around many of our major cities, so-called "grey belts" are found, comprised of structures that have become obsolescent before they have reached the end of an otherwise useful life. We must find new building materials, new structural forms, new methods of construction and reconstruction—so that the structures we build in the future can be more economically changed or replaced.

The ground facilities for transportation are not only part of environment but exert a dominant influence on the development of environment as a whole. Mobility is one of man's basic needs, yet we are approaching a transportation crisis in this country—a crisis of which traffic strangulation in our cities today is but a single facet. Our dilemma of transportation is not going to be solved just by building more expressways or by tax relief for railroads, however important such steps may be. We need new forms of transportation, and we need to co-ordinate its various forms into total transportation systems. We need, too, to develop technical possibilities such as automatic controls for transportation, so that available space for mobility can be utilized more fully and safely.

I believe that from a consideration of these five areas —radioactive wastes, water shortages, air pollution, obsolescent structures, and traffic congestion—chosen somewhat at random from among the problems that must be faced primarily by civil engineers, my reference to the rate at which man seems to be poisoning and in some instances strangling the environment in which he lives becomes justified. These and other typical problems of civil engineering have three common denominators:

1) They all deal with the fulfillment of human needs on a large scale;

2) They all deal with the land-water-air environment; and

3) They all deal with the adaptation and control of that environment—using the term environment in a broad sense that includes land-based structures and facilities as well as the land, water, and air themselves.

These three common denominators may, if we choose, form the basis for a unifying theme of purpose for civil engineering. The theme suggested after serious consideration of this matter by a committee of my colleagues is: *The fulfillment of human needs through the adaptation and control of the land-water-air environment.* Environment is essential to well-being wherever man prevails—in the underdeveloped countries of the world as well as in our "overdeveloped" metropolitan areas—and it will be equally important, although in different ways, as man probes into space and finally lands on the moon.

The Roots and Tools

This theme in no way limits the scope of civil engineering; such basic objectives as mobility, shelter, health, and the like, are—and will always remain—among man's greatest needs. Neither does it suggest that there will not always be areas of proper specialization within the field. It does imply, however, that whether one processes fresh water from the oceans or disposes of fission wastes in glass capsules, designs monorails for a city or teams up photogrammetry with digital computers for automatic route location, builds plastic structures or stabilizes soil with chemicals, harnesses the waters in the interior of Africa or constructs DEW Line stations on the Greenland icecap, remains earthbound while doing such things or sallies forth to distant planets, one is in all cases striving to fulfill human needs through the adaptation and control of the land-water-air environment.

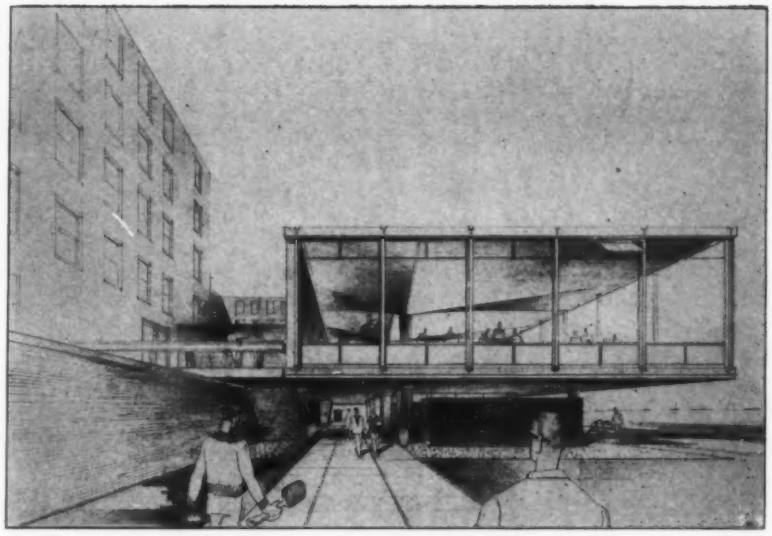
It suggests, too, that since civil engineering deals with man as well as with his environment, it has its roots not only in the physical sciences but in the earth, life, and social sciences. Building from these roots, the civil engineer is concerned with the engineering of components such as the structures, ground facilities and processes that comprise and control environment. Tomorrow he must go beyond this: To truly serve man's needs, these components must be engineered into environmental systems such as those involved in water resources and transportation—and these are systems that involve social as well as physical forces.

Modern technology, which in part has led to some of our great environmental problems, also provides powerful new tools to aid in their solution—analytical tools such as statistics and probability, operations research, and machine computation. We seem to be on the threshold of the capability of bringing these weapons to bear in a systems approach to the furthering of our objectives and thus of becoming the instigators of significant change in the engineering of man's environment.

With such a theme, we can offer in civil engineering a sound and liberal brand of education that should have appeal to young men who are not only challenged by the intellectual rigor of science and mathematics but who, at the same time, are motivated to exploit the frontiers of science and technology for the direct benefit of man and of society.

New Dining Hall and Garage Will Open Next Year

A NEW DINING HALL for M.I.T. students, and a new parking facility for the Institute community, are nearing completion this fall. Construction of an addition to the Burton House dormitory and a four-story garage east of the old Radiation Laboratory began last summer and will be completed by the spring of 1961.



Students will use the addition to Burton House in many different ways.

The New Meeting Place

The structure that is being added to the campus side of the former Riverside Apartment Hotel on Memorial Drive will provide a dining and gathering place for more than 550 students. It will be connected both to the section of the dormitory known as Alfred Edgar Burton House, in honor of the late Dean Burton, and to the section called Conner Hall, in memory of Arthur J. Conner, '88. It has been so designed that it can be divided later, if desired, into two dining rooms, each with its own serving counter. It will be used not only as a dining room but also as a study hall and for lectures and dances.

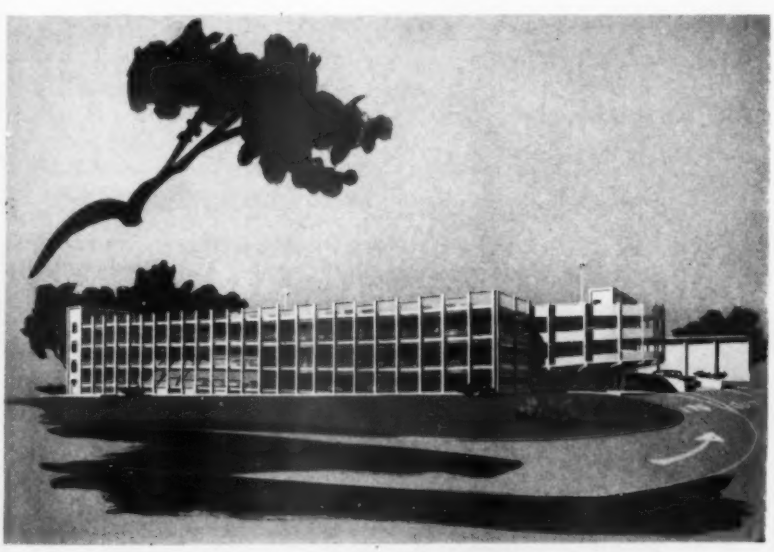
Building, equipping, and furnishing this structure will cost about $700,000. The Alumni Fund has contributed $300,000, and the Institute proceeded with the work this summer with the help of a $400,000 loan from the Community Facilities Administration of the Federal Housing and Home Financing Agency.

The 135 by 45-foot, air-conditioned dining hall will be at the level of the second floor of the dormitories. Additional student lounges on this floor may be provided later, and new exterior stairways will give occupants of both Burton and Conner direct access to this level. The hall itself is away from the indented north wall of the existing building, at distances of 16, 24, and 52 feet; the space between is used for a new, modern kitchen on the upper level, and for receiving, dry-storage, and mechanical equipment on the lower level. The driveway behind the dormitory is being offset to the north of the dining hall, to a position appropriate for long-range campus development to the west. A broad walk, flanked by a brick bearing wall, passes beneath the dining room; it screens the delivery areas and leads to the two new entrances. Storage space for students' trunks and bicycles is also provided beneath the dining hall, but the top of the brick walls enclosing these storage areas is being kept well below the ceiling slab, so that the hall's structural system will be clearly expressed.

The roof of the new hall will be in five sections, each 27 by 45 feet and consisting of hyperbolic paraboloids of reinforced concrete veering out and up from a central column. The line of the five columns is off-center in the hall—to provide less visual obstruction, and to emphasize the outlook from the hall over the Institute's playing fields.

Both this dining hall and the new parking garage will be supported by pressure-injected footings, known as Franki piles, such as were used for the foundation of the David Flett du Pont Athletic Center on the west campus.

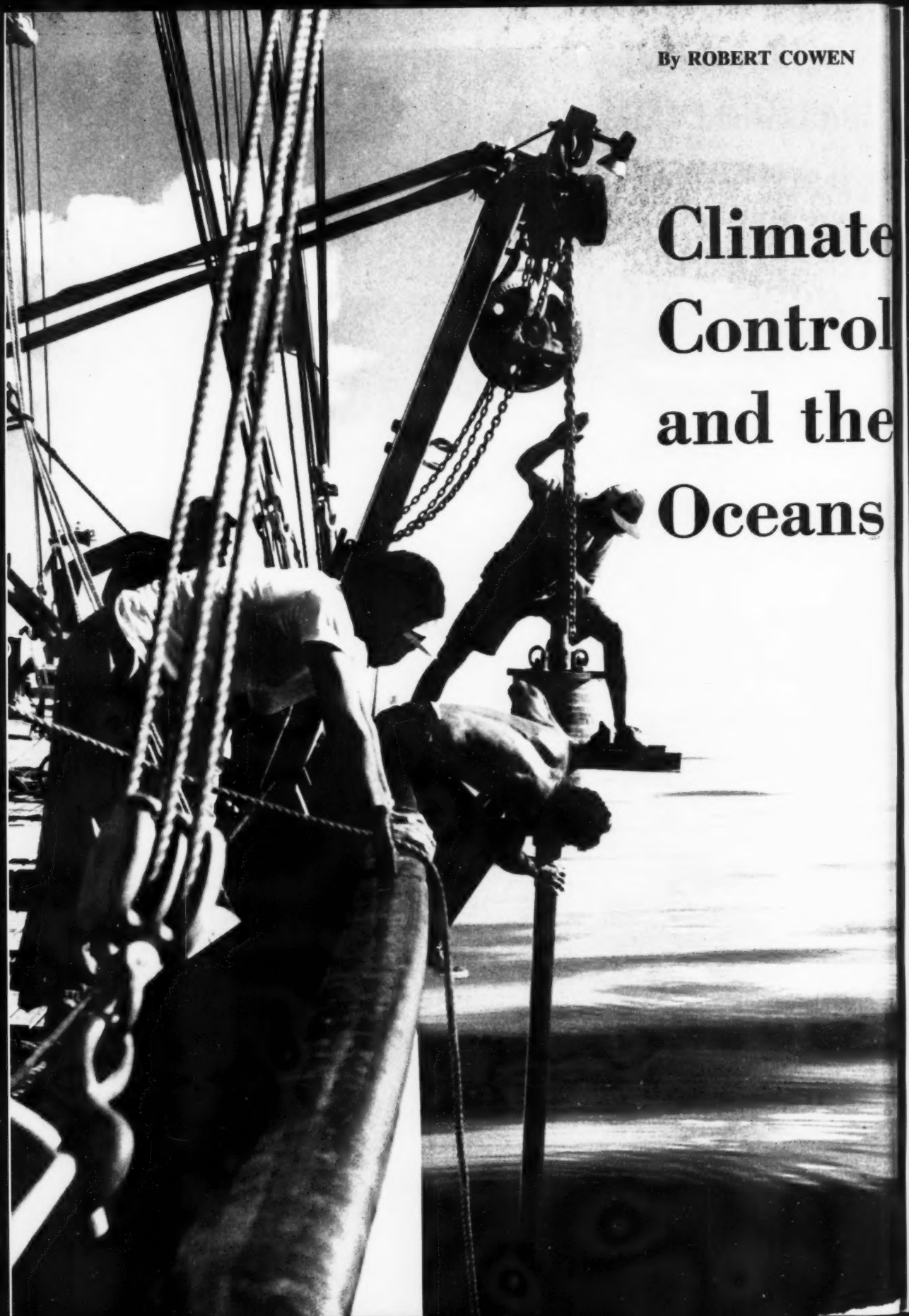
(concluded on page 52)



This new parking facility at M.I.T. will accommodate more than 400 cars.

By ROBERT COWEN

Climate Control and the Oceans



We are performing a carbon-dioxide experiment which may change our climate—and talking of further alterations in our environment without adequate knowledge of the earth's big flywheel

ROBERT COWEN, '49, *is natural science reporter for* The Christian Science Monitor, *and lives in Concord, Mass. His new book,* Frontiers of the Sea, *published this year by Doubleday & Company, Inc. ($4.95), covers many problems studied at M. I. T. This is an excerpt from it.*

THE CLIMATIC influence of the oceans is familiar to all who live near the sea. Here seasonal extremes are less severe. Winters are milder and summers cooler. The warming influence of the Gulf Stream, which moderates the climate of Western Europe, is famous. This direct tempering of regional climates, however, is of secondary importance. The major climatic role of the sea is its function as the thermodynamic flywheel. Actually the icecaps are part of this flywheel mechanism too, for they can absorb and release heat by melting and freezing. But the oceans have by far the larger capacity.

If all of the solar energy reaching the earth for two and a half years were marshaled for the purpose, it would just be enough to melt the Antarctic icecap. Yet this same energy would add only about two degrees Fahrenheit to the ocean's average temperature. This great capacity means that a prodigious excess of heat can be stored in ocean waters for long periods of time without appreciably affecting the temperatures of the lower atmosphere. Conversely, the oceans can give up a large amount of heat to the air with hardly any change of average water temperature.

On the other hand, the ocean flywheel can't function efficiently unless there is effective overturning of its deep waters. If the ocean doesn't regularly bring deeper water to the surface and vice versa, its ability to exchange heat with the atmosphere is severely hampered. From the oceanographer's viewpoint, the puzzle of how the ocean flywheel operates breaks down into two broad questions: What are the mechanism and rate of overturning of the ocean waters? What is the "time constant" of the thermal flywheel? In other words, is the overturning of the oceans and their interchange of energy with the atmosphere characterized in terms of decades, centuries, or millennia? Is the overturning a more or less continuous process or, as one expert put it, "intermittent like the flushing of water in a bowl?"

At present, oceanographers can only guess at the answer. . . . Without a clear picture of how the ocean overturns and with no accurate time scale for interaction with the atmosphere, oceanographers and meteorologists alike are at a loss to explain adequately the general mechanism of the earth's climate. Now man, with his carbon-dioxide-producing industry, has become yet another unknown modifying factor.

The influence of this new and geologically unique factor may be operating in any of several directions. It could be tending toward a new ice age or could just as likely be producing another great tropical epoch like that prevailing when coal and oil deposits were laid down. Perhaps its influence is more moderate than such extremes suggest. The interactions are so involved that experts do not yet know how to sort them out. One thing they are sure of—this influence is at work on a scale to dwarf all previous changes man has made.

Climates long ago are learned from cores of material from the ocean bottom. At the left, a piston coring tube is seen being lowered from the Atlantis. Sediment cores 30 feet long have been obtained this way.

Our Fires' Effect

To be precise, the carbon dioxide experiment began with the industrial revolution, when men started burning fuels in unprecedented amounts. Since the beginning of that revolution they have produced something like 12 per cent of the total carbon dioxide already present in the air. The capacity of the oceans to absorb this gas is enormous, however. Most of the excess produced in the past century probably has been removed in this way. The next century will be different. Dr. Roger R. Revelle of the Scripps Institution of Oceanography, estimates that 1,700 billion tons of carbon dioxide will be produced by man's fires during those hundred years. This is about 70 per cent of the amount of that gas now in the atmosphere. However, no one knows how much of this actually will accumulate.

Dr. Columbus Iselin (Professor of Oceanography at M.I.T.) has outlined a theory which, though it is speculative, at least indicates what might happen. He first points out that oxygen measurements below 800 meters' depth in the Atlantic show less oxygen content than they did 30 years ago, indicating that at least the Atlantic Ocean waters are not being renewed by overturning at the present time. The reason for this, he explains, may be the relatively warm climate of the past few decades. The ocean won't overturn until the climate turns colder. Unless this happens, the polar regions won't be cold enough to produce the cold dense water that sinks and generates bottom currents which, flowing toward the equator, push warmer water to the surface and cause the oceans gradually to overturn. At the same time, he adds, if the ocean doesn't overturn, its ability to exchange heat with the atmosphere will be hampered and its ability to absorb carbon dioxide will be cut down.

These effects would probably have an important but unpredictable influence on the weather. If the ocean's ability to soak up carbon dioxide is reduced, this would increase the greenhouse warming effect as more of that gas accumulated in the atmosphere. Thus there may be a climatic persistence effect due to the oceans which enhances warming after such a trend has started. Once the climate has warmed up to a certain point, the oceans would stop overturning. Because less carbon dioxide would be removed from the atmosphere, this in turn would accentuate the warming trend, which would then tend to persist.

Iselin says that something like this may have happened in climatic regimes in the past. He points out that if oceans don't overturn, the oxygen in deep water is gradually used up. In such oxygen-depleted water, marine life ceases. Organic refuse, formerly eaten or decomposed by deep-water creatures and micro-organisms, will accumulate on the ocean bottom as it rains down from the relatively abundant life of the surface waters. These are conditions for forming coal and oil. At the present rate with which deep-water oxygen in the Atlantic seems to be decreasing, Iselin estimates this oxygen-depleted condition would be reached in a thousand years.

Added to any such persistence effect of the oceans is the cumulative influence of the flood of man-made carbon dioxide. "This is the big climatic experiment," Iselin says. "One of its questions asks if we are helping to slow down ocean overturning and its attendant effects on the weather. Are we making a tropical epoch or are we, perhaps, starting another ice age? We don't know enough about the oceans and the weather yet to be sure which way the effect will go."

Setting a buoy in the Gulf Stream system to study subsurface direction of a current, from the R. V. Crawford.

What is needed are accurate world-wide carbon dioxide measurements. The first really good census of this gas in air and ocean was made during the IGY. With these data, charts are being drawn up indicating sources and sinks of the gas and its movements and accumulation around the world. In other words, they help define the regions where carbon dioxide is being added and, by comparison between charts drawn for different times, aid in estimating how fast it is being added. Likewise, they trace out regions where the gas is absorbed and help fix the rate at which it is removed from the air. This is an important step in determining the carbon dioxide influence on terrestrial heating and on the weather.

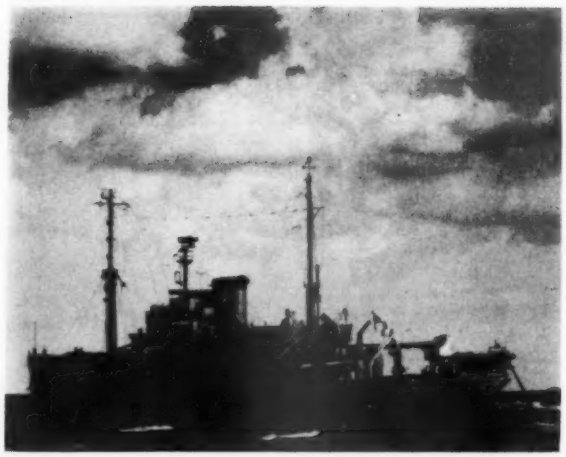
But whether or not men are hastening its advent, there is reason to believe that the earth is heading into another ice age. Four times in the past million years the ice sheets have advanced, and four times they have retreated. We now seem to be living in an interregnum between the last advance, which ended 10,700 years ago, and a new glaciation that may come in the millennia ahead. If geophysicists understood the mechanism of the ice ages, they would probably be able to assess the course the carbon dioxide experiment will take.

Frozen Paradox

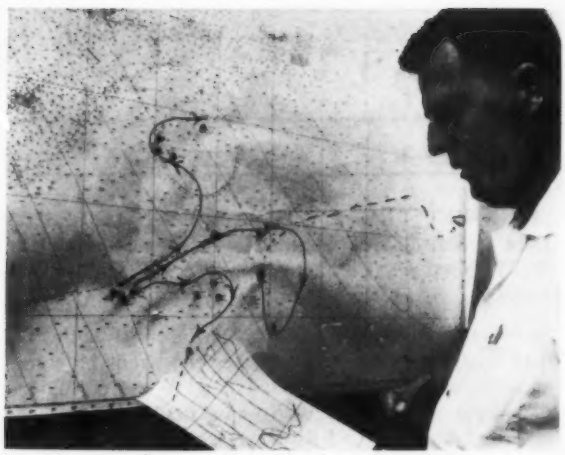
The earth is by nature a semi-tropical planet. It has been relatively warm and moist throughout much of geological time. For 90 per cent of the past half billion years, the post-Cambrian eras, its average surface temperature has been 72 degrees Fahrenheit in contrast to the present average temperature of 58 degrees. Tropical and subtropical climates prevailed to high northern and southern latitudes. Even the poles were ice-free. For such a dulcet planet, the terms "ice age" and "glacial epoch" seem paradoxical. Yet every so often the heat engine that maintains the climatic balance shifts gears, and ice sheets creep over land and sea.

There have been three of these glacial epochs since Cambrian times and at least five before that. They seem to have come at more or less regular intervals of 250 million years. Each has lasted only a few million years and may have been split into several distinct ice ages when glaciers alternately advanced and retreated. The last glacial epoch had five such advances and retreats. The Quaternary period, which includes the Pleistocene glacial epoch and which began a million years ago, has already had four ice ages. A fifth ice advance may come within the next 75,000 years or so, although the present climate is gradually warming up. Dr. Hurd C. Willett of the Massachusetts Institute of Technology, a meteorologist who has specialized in climate trends, estimates that the world at present has come two-thirds of the way between the climatic extreme of an ice age and the warm peak of an interglacial period. What causes the periodic icy departures from the earth's normal climate? Why does the great heat engine shift gears? This is another fundamental question for which geophysicists can only guess at the answer.

There has been a plethora of theories to explain the shifts of climate—far too many to detail them here.



Towing a chain down to 600 feet from the R. V. Chain of Woods Hole during the examination of the Gulf Stream.



A. R. Miller comparing drifts of radiotransponding buoys used in survey of the Gulf Stream with ocean temperatures.

Most of them, however, shake down into one of three general types. They either explain climate shifts by astronomical changes in the earth's relation to the sun; by strictly geophysical causes such as migrations of continents and poles, the uplifting of mountains, or the spreading of volcanic dust; or finally by solar effects—that is, changes in the energy output of the sun. These different types of theories were reviewed in the light of modern knowledge during a two-day conference on climatic change held several years ago by the American Academy of Arts and Sciences. The papers presented there were published in 1954. Although they are five years old at this writing, they still stand as an authoritative review of the field.

The consensus of the conference was that, while many things may influence the earth's climate, variations in the sun's output of radiation seem to be the one principal factor that could account for world-wide climatic changes, especially the major glacial epochs. For example, A. J. J. van Woerkom of Yale University explained how some ice-age theories have been built on the fact that certain slight and well-known variations in the earth's orbit and the orientation of its polar axis change the distance between the planet and sun from one winter (or summer) to the next and slightly alter the angle of incoming sunshine. These things would change the amount and nature of solar heating from one winter (or summer) to the next. There have been a number of theories that suggested these astronomical changes in the earth's relation to the sun could become significant enough to start the icecaps growing. But van Woerkom's calculations show that, while the changes would probably have some effect on climate, they are too small to account for glaciation.

Most geophysicists today do not believe there is enough evidence to support ice-age theories based on such geophysical effects as major shifts of the poles or the drifting about of continents either. But mountain building is something else again. C. E. P. Brooks, the great British climatologist, has noted that, just as the earth's normal climate is warm and moist, its normal geography is one of low-lying continents and widespread seas. And, just as the climate has been periodically interrupted by glacial epochs, the geography has sometimes been drastically altered by epochs of mountain building. Brooks and others have thought the effect of the uplifted land in altering the circulation of air and oceans would be a sufficient cause for glaciation. Critics such as Willett point out, however, that, while there has never been a glacial epoch without continental uplift and mountain building, there have been epochs of uplifting with few or no glaciers. The current view is that, while uplifted land masses are probably a necessary base for the ice sheets, they can't cause glacial epochs by themselves.

Such periods of mountain building could conceivably be accompanied by enough volcanic activity to fill the air with dust that could in turn cut down the sunshine reaching the surface. Dr. Harry Wexler, '39, director of meteorological research for the United States Weather Bureau, has estimated that changes of about 20 degrees Fahrenheit in average surface temperature are involved between glacial and interglacial periods. He notes that blankets of volcanic dust, or even changes in atmospheric carbon dioxide, of reasonable amounts, could contribute significantly to surface temperature changes in this range. Again there is not enough data to support ice-age theories based on these factors alone. The present balance of opinion among ice-age theorists is that uplifted continents, volcanic dust clouds, and other geophysical effects may be contributing factors, but the variability of the sun is the dominant influence. . . .

Whatever the ultimate cause of climate change may be, our present climate is very sensitive to changes in average temperature. A drop of only four degrees might be enough to bring on an ice age. It would mean a climate cool enough so that summer melting might not be able to remove the winter's accumulations of ice and snow and the glaciers would grow and move southward. On the other hand, the British geophysicist Sir George Simpson has dissented from the assumption that the temperature has to drop to start the glaciers growing. Instead, he has argued that the temperature would have to rise. He pointed out over 20 years ago that the chief result of a general cooling might be a drop in the moisture content of the air and a damping

(Continued on page 42)

Books

SPINDRIFT FROM A HOUSE BY THE SEA, by John J. Rowlands, illustrated by Henry B. Kane, '24; W. W. Norton & Company, Inc. ($3.95). *Reviewed by Frederick G. Fassett, Jr., Dean of Residence, M.I.T.*

"SPINDRIFT," says the author, "is the misty spray that flies from the cresting waves when the winds blow hard and the seas run high. What I have to say is Spindrift of a kind—fragments of life snatched now and then, here and there . . . I have written at random, and in no particular order, of what I have seen and heard, of sights and sounds, of the thoughts and memories, that have made my life so well worth living." What we have, then, is a collection of writings varied in length, in tone, in substance, and in purpose, but all infused with quiet, solid satisfaction for the reader of thoughtful and curious mind. This is no book which a reviewer can tag with a glib classification; on the contrary, this is hearing a congenial and generous man share in amiable conversation experiences and observations marked with the sense and poise of a rich lifetime.

Several of the pieces have appeared in magazines. One "Flight of a Moth," was not so issued, and it is decidedly not easy to say why, for in perceptiveness and understanding this is a most unusual narrative, wherein comprehension of youth and age, of major life and minor life, is given direct, unaffected expression.

The range of the book is broad, from the expectancies and upsets which every housebuilder knows to the isolation of the Indian standing alone under the Northern Lights in the Arctic night.

THE GEOMETRY OF GOLF, by William A. Tripp, '22; Vantage Press ($2.50). *Reviewed by Richard L. Balch, Director of Athletics, M.I.T.*

RATHER than write a book on "How To Play Golf," William A. Tripp has described in a simple, direct fashion what he calculates to be the basic mistakes in physical co-ordination of the golf swing. He admits that *The Geometry of Golf* has much to do with Byron Nelson's statement that: "In golf, it's not who you are, what you are, or what you have that counts. It's 'How badly do you want to win?' "

William A. Tripp

As a person who plays "at" the game of golf, Mr. Tripp's efforts refute many of the old wives' tales having to do with grip, stance, pivot, and so forth. He encourages the average golfer by suggesting that one may accommodate variations in physical strength and stature by simple analysis of the golf swing.

A "Spindrift" illustration, drawn by Henry B. Kane, '24.

This 57-page collection of notes sets forth much that has evolved from pure common-sense analysis. The suggestions having to do with the use of a hammer as being applicable to the wrist action in golf, and the description of the arc of swing, provide a working formula for one interested in decreasing the number of divots afforded the local grounds-keeper.

The author, unlike many, suggests no panacea for the weekend golfer, but does dissect enough of what happens to make more than just interesting reading.

I am sure Mr. Tripp conveys to all the enjoyment he has afforded himself in the analysis of his own game and does provide a framework in which others may consistently get the ball off the tee.

GUIDE TO SAILING, by Leonard Fowle; Chilton Company ($1.95). *Reviewed by John I. Mattill, Director of Publications, M.I.T.*

ANOTHER little book has joined the long shelf of beginners' manuals on sailing. This one—by Leonard Fowle, who faithfully covers sailing for the Boston *Globe* with authority and skill—will win no literary prizes. But it is a competent little summary which any landlubber like this reviewer will find useful and stimulating. And if he happens to come from M.I.T., his interest in it will be far sharper.

In his introduction Leonard Fowle expresses his debt to Walter C. Wood, '17, M.I.T.'s Sailing Master, who he says "has probably taught more people to sail than any man in the United States." Those who have learned to sail with Jack Wood know the unique values of his M.I.T. Shore Trainer in showing the fundamental maneuvers of a sailboat in every kind of wind. An outstanding feature of Leonard Fowle's book is his use of this same method to describe how to manage a sailboat under every sailing condition.

(Book news is continued on page 60.)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

It has often been mentioned in these messages that in order to produce the best possible product at the least possible cost, it is a good idea to take your suppliers into your confidence . . . tell them your problems . . . seek their aid.

The following incident is a striking example of the advisability of doing just that.

The Dayton Precision Manufacturing Company, maker of the commutator you see illustrated, was having difficulties with the ferrous metal it was using for the hub; for not only did the rod from which the hubs were fabricated have to be drilled but it also had to be able to withstand a flanging operation. Their Chief Engineer decided to discuss this with one of Revere's Technical Advisors.

After a thorough study of the problem Revere Brass Rod of a certain alloy was recommended and samples were furnished. The manufacturer found the machinability of the brass rod to be outstanding, being readily and speedily drilled. Also, it withstood the flanging operation . . . a set of manufacturing conditions where only brass, the right kind of brass, outshines all other metals and alloys.

The final score showed that the low first cost of the brass rod, plus the fact that it could be machined faster and more easily than ferrous metal, resulted in a superior product at a saving in production cost. A further advantage was the added sales appeal of the brass hub.

There you have another example of how Revere in collaboration with the manufacturer's engineering department, helped "fit the metal to the job," which resulted in a better part at the least possible cost.

Revere, a supplier, is conscious that still other suppliers can often collaborate to help customers produce a superior product for less money.

And because almost every industry you can name is able to cite similar instances, we suggest that no matter what your suppliers ship you, it may pay you to take them into your confidence.

REVERE COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
Executive Offices: 230 Park Avenue, New York 17, N. Y.
Distributors Everywhere

Institute Yesteryears

25 Years Ago

PRELIMINARY registration figures showed a total 1935-1936 enrollment of 2,544 (up 59 from 1934-1935), including 517 (up 37) in the Graduate School, and 568 (up 20) entering freshmen of the Class of 1939.

Further pleasant news was revealed by the second Annual Report of Horace S. Ford as Treasurer of the Institute, covering the fiscal year 1934-1935. The operating budget of $2,695,000 had been balanced with a margin of $238.73. "The Institute's cumulative deficit on account of operations since 1865 now stands at $24,951.22," wrote Mr. Ford.

¶ Among new members of the Institute Staff were Associate Professor Ernst A. Hauser in the Department of Chemical Engineering and Instructor Irwin W. Sizer in the Department of Biology and Public Health.

50 Years Ago

THE EDITOR of the Review thought, "The figures connected with registration this year [1910-1911] are unusually impressive. The total registration is 1,506, which has been exceeded but three times in the history of the Institute, and these were the three years immediately preceding the increase of the tuition fee from $200 to $250 and also the raising of the entrance requirements."

¶ In the autumn of 1910, President Richard C. Maclaurin wrote of the Institute:

"It does not seem proper that the 50th anniversary of its foundation should pass without special comment. It has, therefore, seemed wise to adopt a suggestion made by the Alumni Council and celebrate this anniversary by holding a Congress of Technology on the 10th and 11th of April next.

"It is hoped that at this Congress men of eminence will be present to set forth some of the broader results of the application of science to industry which it is the main purpose of the Institute to further, and to indicate the gain in industrial efficiency that may be expected from the extension of its influence."

75 Years Ago

REGISTRATION for 1885-1886 totalled 609, an increase of 30, or five per cent, over 1884-1885. Of the 629 members of the student body, 387 (nearly two-thirds) came from Massachusetts; 78 (over a fifth) were from other New England states.

¶ "Once again we have met at the Institute after our long vacation," observed the editor of *The Tech*. "Last May we left with feelings of pleasure at having finished a year of hard work, and the prospect of a pleasant rest during the summer; and now we return with the same feelings at the thought of meeting our classmates once again, which are mingled with regret at finding some of them absent."

Matters were going on differently, however, with respect to "foot-ball," the editor was pleased to admit. "Its prospect . . . this year," he considered to be "most encouraging. The old foot-ball association being defunct, a new one has been formed in its stead, which, so far, has shown itself to be very wide-awake and enterprising. It has been proposed to form a Northern Inter-Collegiate Foot-ball League, to include Amherst, Williams, Tufts, and Dartmouth colleges, and Technology. . . .

"Not for several years has so much interest been shown in foot-ball at the Institute, as at present a large number of men have been trying out for the team. Nearly all of last year's eleven are here this year, and it will be greatly strengthened by some new additions. The team is to go into strict training, and will probably have a trainer."

The editor's optimism proved well-founded for, during November, 1885, the "Techs" successively defeated Williams by a score of 14-0, Tufts by 110-0, Amherst 32-0, and Amherst again in a return engagement by 80-0. This put them in a tie with Williams for the league championship, but on November 25 Williams defeated the "Techs" 18-10.

All this prompted the editor to comment: "At any rate, there are no goose-eggs in our *league* record this year, and in total number of points won the Techs still stand ahead." *

100 Years Ago

AN APPLICATION, in the handwriting of William Barton Rogers, was made to the General Court of the Commonwealth of Massachusetts, in which he and 18 other "subscribers [did] respectfully pray for an Act of Incorporation for an Institution to be entitled MASS. INSTITUTE OF TECHNOLOGY, having for its objects, the advancement of the Mechanic Arts, Manufactures, Commerce, Agriculture and the applied sciences generally, together with the promotion of the practical education of the industrial classes, and proposing to attain these ends by the threefold agency of discussions and publications relating to industrial art and science; by a Museum of Technology, embracing the materials, implements and products of the practical arts and sciences; and by a School of Industrial Science, for instruction; by lectures, laboratories and other teachings, in those several departments. . . ."

The subscribers did also "respectfully pray that a section of land on the Back Bay may be reserved and granted, on such terms and conditions as may seem needful for the use of said Institute, such section being situated adjoining the sections asked for by the Boston Soc. of Nat. History and the Mass. Horticultural Society."

On November 20, 1860, the Secretary of State approved this application for publication in the *Boston Daily Advertiser* after which it was forwarded for action by the General Court when that body assembled the following January.

---

* As noted by Dean S. C. Prescott, '94, in his *When M.I.T. was Boston Tech*, "Football had not then reached the dominant position it later assumed in college life, and games were played for enjoyment, without expensive equipment or coaches. The game persisted lamely at the Institute until 1906, when student government decided that M.I.T. men had neither the time for training nor the means to keep up intercollegiate competition."

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To formulate rules for automatic language translation is a subtle and complex task. Yet, significant progress is being made. During the past several years large amounts of Russian text have been translated and analyzed at Ramo-Wooldridge's Intellectronics Laboratories using several types of existing general purpose electronic computers.

Many hundreds of syntactic and semantic rules are used to remove ambiguities otherwise present in word-for-word translation. The considerable improvements that have been effected during the progress of this work indicate that it may be possible within the next year or so to produce, for the first time, machine translation of sufficient accuracy and at sufficiently low cost to justify practical application. Electronic computers are also invaluable for other language research activities at Ramo-Wooldridge.

Techniques for automatic indexing, automatic abstracting, and other aspects of communicating scientific information are also being investigated. Research and development at the Intellectronics Laboratories will eventually lead to electronic machines capable of carrying on self-directed programs of research and analysis and "learning" by their own experiences.

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Climate Control and the Oceans

(Continued from page 37)

down of the atmospheric circulation. This could cut down snow and rainfall so much that ice would be unable to accumulate in spite of the cooler summers. Moreover, the Arctic seas would freeze, cutting down even further the amount of moisture and snowfall in northern latitudes. A general warming would have an opposite effect. Increased evaporation from the oceans would load the air with moisture. Winter snowfalls would be heavy—too heavy for summer melting to keep up with—and glaciers would start to grow. There would be more cloudiness, helping to increase the amount of incoming sunshine reflected back into space. If the warm-up continued strongly, summer melting would, of course, predominate and the ice sheets would again melt. But a slight warming, according to this theory, could conceivably start an ice age. No expert today understands the climate mechanism well enough to confirm or refute this theory. Thus it has remained a possibility that has to be considered in evaluating world climate trends. It is one reason why experts don't know what the carbon dioxide experiment will lead to.

Most glacial theories have not had much to say about the climatic role of the oceans. The action of the thermodynamic flywheel is not understood in any event, while the main job of transferring heat from equatorial to polar regions is generally believed to be carried out by the atmosphere. Thus glacial theorists have tended to study the effect of solar and other possible influences on the atmospheric weather patterns and to assign the oceans a secondary role. Recently, however, a radically new theory has been proposed in which the ocean is the key factor, at least as far as the Quaternary ice ages are concerned.

Atlantic Thermostat

It would seem obvious that during an ice age the polar waters of the Arctic Ocean would be frozen as solidly as everything around them. However, by turning their backs on the obvious and working out what might have happened had this ocean been open during the past four ice ages, two geophysicists have come up with a remarkable theory of climatic change in which the sea acts as a kind of thermostat. They also conclude that the earth is heading inexorably into still another ice age in spite of its present warming trend. The geophysicists are Dr. Maurice Ewing and Dr. William L. Donn, associate professor of geology and meteorology at Brooklyn College. Here is the way they think the ocean thermostat may work.

The Arctic Ocean communicates with the rest of the seas over a narrow sill between Greenland and Norway, most of which is less than 300 feet deep. Its connection through the Bering Strait with the Pacific is too restricted to count. If the waters of the North Atlantic and Arctic oceans could freely interchange over this sill, the latter wouldn't freeze over. This, according to the theory, was the case before and during the past four ice ages of the present epoch. It would have meant a radically different weather pattern in the north than is found there today. The Arctic is cold enough now to form glaciers. But there is so little snowfall that summer melting can more than keep up with the winter accumulation. With an ice-free Arctic Ocean warmer than the surrounding land and moistening the air, the situation would be different. Heavy snowfall would come down and build up into glaciers, changing into steel-hard ice under its own weight. These ice sheets would begin to flow south, bringing severe weather with them, until centuries later they engulfed regions as far south as New York and Paris.

Meanwhile the growing ice sheets would withdraw water from the oceans, lowering sea levels around the world. At some point the water level would drop so low that the interchange across the North Atlantic sill would effectively cease. The Arctic Ocean then would freeze, cutting off the precipitation supply for the glaciers and signaling the end of the ice age.

Donn and Ewing say that something of this sort seems to have happened at the end of the last ice age at least. They have found indications in bottom cores taken in the Atlantic and Caribbean that the waters there may have suddenly warmed significantly about 11,000 years ago. This sudden widespread warming might be easily explained if the Arctic froze over and stopped exchanging its cold waters with the Atlantic.

Once the Arctic did freeze and cut off the snowfall, summer melting would again have the upper hand. The ice sheets would retreat, giving up their imprisoned waters to the oceans. Sea level now would start to rise, until at some point the warm waters of the Atlantic would thaw out the Arctic and start the ice cycle all over again. . . .

"Adjusting" the Heat Engine

While any present-day schemes for changing climate are either pipe dreams or precocious visions, experts foresee the day when serious proposals along this line will be advanced. Writing in *Science,* Dr. Wexler notes that "when serious proposals for large-scale weather modification are advanced, as they inevitably will be, the full resources of general-circulation knowledge and computational meteorology must be brought to bear in predicting results." In this way, he adds, men can perhaps avoid "the unhappy situation of the cure being worse than the ailment." Scientists will have had to do a good deal of advance research if they are to evaluate such proposals. Some of the weather-modification schemes currently discussed, while impractical today, at least indicate areas in which some of this research will have to be done.

Wexler himself has suggested a way to speed up the melting of the Arctic sea ice. He thinks a few well-placed hydrogen bombs might do the trick. It would take 10 bombs of 10 megatons each (the equivalent of the explosive energy of 10 million tons of TNT). Setting these off under water might throw up enough steam to blanket the Arctic Ocean in an ice fog that would substantially cut down the heat escaping from that region by radiation. This, Wexler says, would speed up the melting tremendously.

Thawing out the Arctic is a favorite project with would-be climate tinkerers. It would pay off immediately in ice-free northern harbors and by shortening the sea journey between Atlantic and Pacific ports by thou-

(Concluded on page 44)

"Locked In"—or Out?

The investor who says, "I am locked in—my profits are so large I can't afford to sell and pay the taxes," will do well to take a fresh look. He may be following his emotions rather than logic.

If the stocks that he owns are not the best for his purpose, he is locking himself *out* of the greater benefits he could obtain by replacing his present holdings.

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Climate Control and the Oceans

(Concluded from page 42)

sands of miles. It could raise the average temperatures at latitudes of London, and New York, or Moscow by as much as 10 degrees Fahrenheit. Besides Wexler's bombs, other schemes include the spreading of heat-absorbing soot or lampblack over the ice and even damming the Bering Strait and pumping in warm water from the Pacific. All of these schemes, even if they were practical to carry out, have a fatal weakness. As Wexler himself points out, unpredictable side effects could outweigh the supposed benefits. The Ewing-Donn theory suggests that unfreezing the Arctic would start another ice age, while Simpson's theory predicts a similar effect.

A different sort of climate-modification scheme has been suggested by Henry Stommel (Professor of Oceanography at M.I.T.) to avoid the ice age that may be creeping up on us—suggested, that is, with tongue in cheek, for Stommel thinks present knowledge too scant for such speculation. He would do it by damming the Strait of Gibraltar. This would take only about 10 times as much fill as the Fort Peck Dam in Montana and would effectively stop the flood of salty Mediterranean water into the North Atlantic. Over several decades the salinity of the Atlantic would then drop, lowering the general densities of its water to the point where cold Arctic water wouldn't sink at all. If this water couldn't sink below the northward-flowing waters of the Gulf Stream, the latter, which now flow up to the Arctic, would be diverted southward and held in a practically closed system within the North Atlantic. Then the interchange of warm water between Atlantic and Arctic oceans would be checked, and any ice age tending to develop along the lines of the Ewing-Donn theory would be blocked.

Commenting on this in the *Scientific American*, Stommel has neatly summed up the status of such schemes today and the great need for more basic research. "Common sense rebels against such an argument," he wrote. "It is hard to imagine so fantastic an effect from so small an intervention by man. And indeed the argument is loaded with unproved assumptions and tenuous speculations. We could construct an equally plausible argument that the same stratagem might cool rather than warm the earth. I cite this entertaining fantasy only to show that we need a great deal more information before we can begin to talk knowledgeably about altering the climate. All such speculations merely illustrate how little actual knowledge we have and how valuable it would be to develop a quantitative understanding of the ocean circulation."

M.I.T. on TV

Two TV shows to be broadcast this fall by CBS were prepared as part of the observance of M.I.T.'s centennial. One, "The Thinking Machine," was to be telecast by many stations at 10 P. M., E.D.S.T., October 26; the other, "Big City, 1980," will be aired first at 9:30 P. M., E.S.T., November 21.

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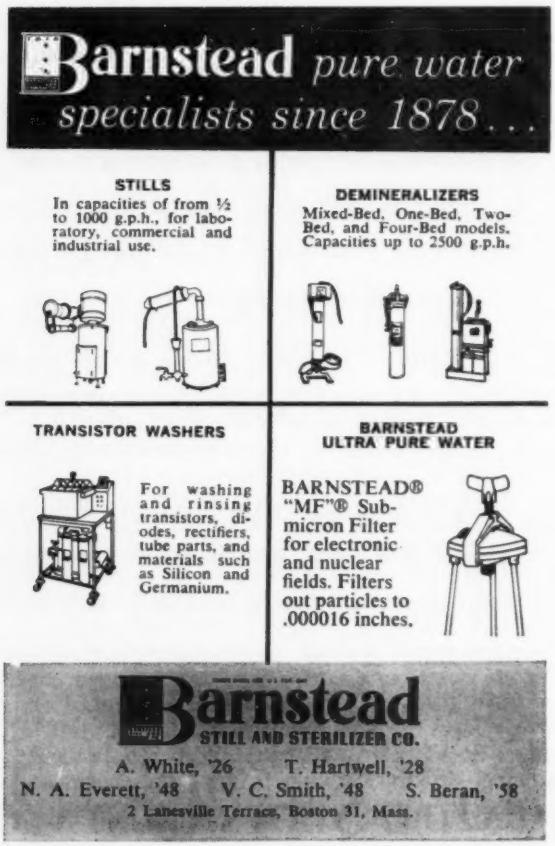
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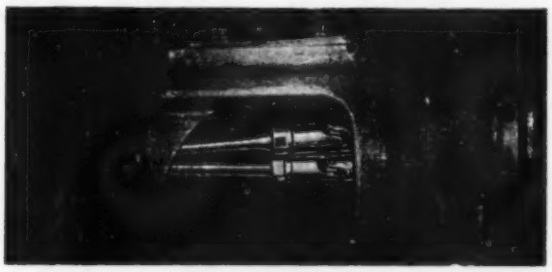

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Feedback

(Continued from page 3)

fort) to let (or, if you will, to *lead*) students to "discover" and develop mathematics by their own efforts (more or less)—or, is it wiser to tell them what to do and how to do it?

If we are to have a really enjoyable argument we shall probably need one or two ground rules. Mathematics and Pedagogy (otherwise known as Education) have lived so long on opposite sides of the cyclotron that they have gradually and conscientiously acknowledged a mutual obligation to be bad neighbors. It may be partly for this reason that discussions about "teaching" or "learning" are normally refereed according to one or the other of two extremes.

One extreme holds that there can be but one Scientific Method, and that this is Experimentation (meaning that, if you take a few children, ask them to write answers to enough foolish questions, and employ enough arcane statistical methodology, you are sure to succeed in measuring a few possibly irrelevant variables—and, at the very least, you cannot easily be refuted).

The other extreme holds that any *interesting* question can only be settled by rhetoric. (Only a fool or an engineer steps into a lab—unless, perhaps, it is air-conditioned.)

The two questions under discussion relate to facts about human behavior. I propose that the matter can best be settled by some compromise system of scoring—I, myself, would not feel comfortable with an intelligent discussion largely unsupported by experiment (or, at least, by experience), nor with a program of "testing" and "control groups" and "evaluation" that leaned heavily on tables of random numbers and such-like, while sedulously avoiding even the slightest suspicion of any dependence upon human judgment, human insight, or human intelligence.

I have, in fact, a suggestion. My colleagues and I have amassed a large library of the tape recordings of actual classroom lessons, such as:

Some fifth grade children are asked whether there might be any open sentences that will be *true* for *every* correctly made substitution. They decide that these may qualify:

$$\square \times 0 = 0$$
$$\square \times 1 = \square$$
$$3 \times \square = \square \times 3$$
$$4 \times \square = \square \times 4$$
$$1066 \times \square = \square \times 1066$$
$$\square \times (\square + 1) = (\square \times \square) + \square$$
$$(\square + 3) \times (\square + 3) = (\square \times \square) + (6 \times \square) + 9$$
$$(\square + \triangle) \times (\square + \triangle) = (\square \times \square) + [(\triangle + \triangle) \times \square] + (\triangle \times \triangle),$$

(Continued on page 48)

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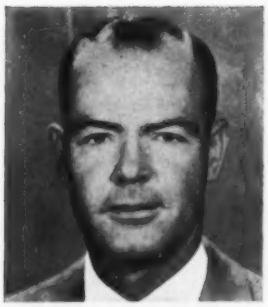

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Feedback

(Continued from page 46)

plus many more. An open sentence that becomes true for every correctly made substitution is called an *identity*. By discussion among themselves, they decide there are two categories of open sentences: those which definitely are *not* identities (as proved by the existence of a "false" substitution), and those which look as though it may be hopeless to disprove them. These latter form a long list of "tentative identities." The children are asked to shorten this list as much as possible, "without losing anything." In response, they devise the technique of making *derivations*, and arrive (after two or three 45-minute lessons) at something reasonably close to the field axioms. The list looks approximately like this:

$\square + \triangle = \triangle + \square$
$\square \times \triangle = \triangle \times \square$
$\square \times (\triangle + \nabla) = (\square \times \triangle) + (\square \times \nabla)$
$\square + (\triangle + \nabla) = (\square + \triangle) + \nabla$
$\square \times (\triangle \times \nabla) = (\square \times \triangle) \times \nabla$
$\square \times 1 = \square$
$\square + 0 = \square$
$\square \times 0 = 0$
$1 + 1 = 2$
$2 + 1 = 3$
$3 + 1 = 4$
•
•
•

At this point in the lesson, one of the ten-year-old children in the class suggests adding this identity

$$\square + \square = 2 \times \square$$

to the list.

Two girls tell him that this is probably redundant, in light of $1 + 1 = 2$.

They realize, however, that this is not a proof. They proceed to make a derivation:

Theorem

$$\square + \square = 2 \times \square$$

Proof

$2 \times \square = 2 \times \square$
$(1 + 1) \times \square = 2 \times \square$
$\square \times (1 + 1) = 2 \times \square$
$(\square \times 1) + (\square \times 1) = 2 \times \square$
$\square + \square = 2 \times \square$

Q.E.D.

A boy remarks at this point that he can prove it another way. He inserts the "ones" where necessary in the following proof, without any help or prompting, although he presumably has never seen anything like this before:

Theorem

$$\square + \square = 2 \times \square$$

(Concluded on page 50)

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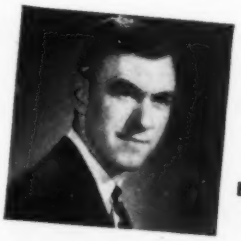

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The chalk moves across the blackboard, pausing, crossing out... yet giving mathematical form to a new idea. This may be the beginning of a command and control system that will not be on-line until the 1970's. It is also the first step toward solving the many complex problems inherent in large scale system engineering.

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MITRE, formed under the sponsorship of the Massachusetts Institute of Technology, is a system engineering organization engaged in the design, development and evaluation of large scale command and control systems. Its convenient location in suburban Boston offers excellent opportunities for advanced study under MITRE's liberal educational assistance program.

Feedback

(Concluded from page 48)

Proof

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Q.E.D.

I find this kind of thing very exciting. These children are really discovering things at what is, for them, the absolute frontier of knowledge.

I do not know whether this sort of instruction—the teacher, as always, mainly stands by and watches—is good for children. I believe it is, and, in order to continue working with these same children, I plan to fly to Weston, Conn., every Thursday and continue to teach them for as many years into the future as is possible and seems desirable. I may thereby gain some evidence one way or the other, although I realize that I shall never satisfy the "control-group-statistics-evaluation" faction, nor the "trying-it-out-is-for-sissies, a he-man sits and argues" faction. I may not even satisfy myself, but then again I may. In the meantime I shall be tape-recording every lesson.

Perhaps the idea behind it all is this: When you ask college freshmen about a problem, they frequently say "I don't believe we've had that . . ." If you give a problem to fifth-graders, they think about it, and often very cleverly. The difference is very pronounced, and is entirely in favor of the fifth-graders. It is my hope that by giving the fullest possible scope to the natural inventiveness, creativity, and originality of these children—instead of telling them things for one year after another—we can develop a new breed of college freshmen. At present I do not know whether this is possible. Fifteen years from now I may.

Concerning the tape recordings: I feel about these tapes as parents do about recent photographs of their children. They are my best evidence that young children *can* discover significant mathematics. If you'd like to borrow one, just write. I may even pay the postage both ways. I believe I can *show* you that the "discovery method" does work.

Syracuse University,
Syracuse 10, N. Y.

P.S. If I may do so without retreating from a properly belligerent tone, I should like to thank Malvin Mayer, '33, for his excellent remarks (May 1960) in defense of the poor lil' □. I, too, hope that ". . . the 'new' notation will give a better comprehension of mathematical principles . . . at an early age." You know, I think it really may!

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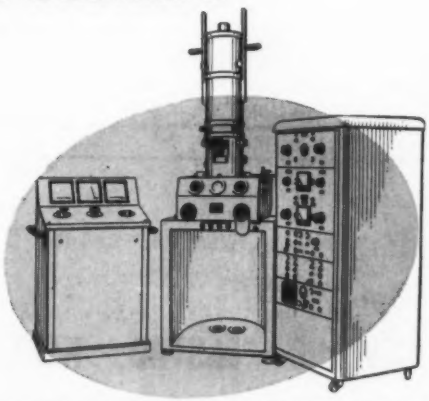

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Dining Hall and Garage

(Concluded from page 33)

Many students and representatives of the Faculty including Professor Howard R. Bartlett, Master of Burton House, and Frederick G. Fassett, Jr., Dean of Residence, participated in the discussions during which plans for the dormitory addition were developed. William H. Brown, '33, and Eduardo F. Catalano of the M.I.T. Faculty, were the architects of this major improvement in on-campus living. Paul Weidlinger of New York was a consultant on the roof construction. Engineering was done by Hayden, Harding and Buchanan of Boston; the contractor is the Kirkland Construction Company of Cambridge.

The New Parking Garage

The capacity of the parking lot on Vassar Street which has been used by Building 20's occupants and others for many years will be more than quadrupled by the $800,000 structure now being erected there. It will be quite different from other parking garages in or near Boston, and will provide ample space for more than 400 cars.

Autos will be parked on each side of long, 60-foot-wide, inclined ramps within the rectangular structure. Eight of these ramps will lead to more parking places on the roof. There will be more space for small cars in a basement beneath the ramps. There will be no columns in the main parking areas, which will facilitate efficient storage of cars of all sizes.

All traffic within the building will move in the same direction. The cars will enter it through a long driveway from Vassar Street, and it will be filled each day from the bottom up. Cars leaving it will spiral down a separate ramp at one end of the building from whatever level they have been left on. This express ramp out of the building, and the absence of columns from the parking spaces, will be the building's most distinctive features.

The main structure will be 228 by 121 feet, and the exit ramp will extend out 50 feet from one end. There will be no heating system, but aluminum-mesh screening around the building between the exterior columns will serve as snow-fencing, enhance the structure's appearance, and help prevent accidents.

The Parking Development Company of Boston designed the building. This company is specializing in parking facilities for schools, churches, and other institutions. It has surveyed the parking problems of M.I.T., Harvard, Boston University, and other New England institutions. At M.I.T., its study three years ago showed that cars begin to arrive early in the morning and the lots fill gradually, but are emptied swiftly late in the day. This garage was designed for this particular kind of traffic flow. Persons using it will not need an attendant's help to park their cars or get them out.

Marvin E. Goody, '51, of Hamilton and Goody, was associated with the Parking Development Company's architectural staff, and engineering service was provided by Maurice A. Reidy, '18, of Boston. The John F. Griffin Company of Cambridge is the contractor.

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THOMAS E. WEIL '49

2d Century Fund Meeting

(Concluded from page 25)

more with than for the Faculty at M.I.T."

After being briefed on the Institute's needs in the Little Theater of Kresge Auditorium, the Second Century Fund's leaders attended a reception at the President's House, and heard Mr. Sloan and Dr. Killian speak at the dinner in Walker Memorial which concluded the first day of the conference.

Details of the organization set up to solicit funds were explained the next morning by Mr. Wilson, Walter J. Beadle, '17, chairman for Individual Leadership Gifts, and Philip H. Peters, '37, chairman of the Area Organization. Questions about taxes were answered by Joseph J. Snyder, '44, Vice-president and Treasurer of the Institute; and "a rehearsal for solicitation" was enacted with suitable stage props by Marshall B. Dalton, '15, chairman of the Corporation Committee on Development, and Gregory Smith, '30, vice-chairman for Area Organization. Tours of the Institute concluded the conference.

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T1BS	.0938	3/16	1-7/16	16	28.50
T2BS	.125	3/16	1-7/16	16	28.50
T4BS	.1875	9/32	2	64	28.50
T6BS	.250	3/8	2-1/2	256	28.50

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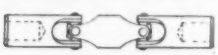
1BS	.0938	3/16	1-1/32	16	5.90
2BS	.125	3/16	1-1/32	16	5.90
3BS	.156	9/32	1-3/8	64	5.75
4BS	.1875	9/32	1-3/8	64	5.75
5BS	.2188	3/8	1-3/4	256	5.75
6BS	.250	3/8	1-3/4	256	5.75

DOUBLE MINI-JOINTS



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DB1BS	.0938	3/16	1-1/2	16	11.80
DB2BS	.125	3/16	1-1/2	16	11.80
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Individuals Noteworthy

(Continued from page 10)

ard & Burns, Inc. . . . *Roger M. Amadon, '48,* as Vice-president, W. F. Schrafft and Sons Corporation, Boston;

Charles N. Winnick, '48, and *Joseph L. Russell, '55,* as Assistant Director for Exploratory Research, and as Director of Research, respectively, of Scientific Design Company, Inc. . . . *David K. Hardin, '49,* as President of the Chicago chapter, American Marketing Association . . . *Richard H. Clough, '51,* as Dean, College of Engineering, University of New Mexico.

Honors to Alumni

MEDALISTS and recent recipients of other distinctions include:

Thomas C. Desmond, '09, the 1959 Distinguished Service Award, by New York Botanical Garden . . . *Robert S. Mulliken, '17,* the Theodore William Richards Medal "for conspicuous achievement in chemistry," by the Northeastern Section of the American Chemical Society . . . *Robert R. Thurston, '21,* and *Louis Tanner, '24,* the Award of Merit for 1960, by the American Society for Testing Materials;

Robert C. Sprague, '23, the grade of Fellow, American Academy of Arts and Sciences . . . *Brigadier General Robert J. Fleming, Jr., '31,* designation as officer of the French Legion of Honor, by the Ministry of Foreign Affairs, for his work as unofficial ambassador of good will of the American people to the French; . . . *Ivan A. Getting, '33,* the Distinguished Service Medal, by the U.S. Air Force;

Colonel Clarence L. Battle, Jr., '46, the Legion of Merit, from the Secretary of the U.S. Air Force, for "successful recovery of a payload capsule from the orbiting satellite" . . . *Ezra S. Krendel, '47,* the Louis E. Levy Medal, by the Franklin Institute . . . *Robert O. Bigelow, '49,* named as "Massachusetts' Young Engineer of the Year," by Massachusetts Society of Professional Engineers.

W. N. Seaver: 1877-1960

WILLIAM NATHANAEL SEAVER, Librarian Emeritus, died last July 17. Mr. Seaver was librarian for the Institute from 1925 until his

(Concluded on page 58)

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Typical Problem: Readout of angular position of a radar encoder is in the form of 16 bits straight binary. You want to convert the 16 bits readout into decimal display expressed in degrees.

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Individuals Noteworthy

(Concluded from page 56)

retirement in 1947 and was largely responsible for the library's steady growth in size and prestige.

After graduating from Harvard in 1900, Mr. Seaver served in the Economics and Sociology Department and Municipal Reference Branch of the New York Public Library. During World War I he was a delegate for the Library War Service of the American Library Association at Edgewood Arsenal, later transferring to the Dispatch Office at Newport News, Va. Prior to his appointment as assistant librarian at M.I.T. in 1924, he also had been librarian of the Woburn (Mass.) Public Library for four years.

After his retirement Mr. Seaver worked on a three-year project to collect and plan a library for the new Instituto Tecnico da Aeronautica being built by the Brazilian government near Sao Paulo. He was a member of the American Library Association, the Special Libraries Association, the New England Association of College Libraries, Delta Upsilon Fraternity, the Melrose Unitarian Church, and the Laymen's League.

Mr. Seaver is survived by his wife, the former Inez Mildred Waite, and three daughters: Mrs. Norman R. Anderson of Towson, Md., Mrs. Donald G. Harrington of Endicott, N. Y., and Mrs. Richard Kimball of Lexington, Mass.

Lowell Institute

AS THE Lowell Institute School at M.I.T. began its 58th year this fall, F. Leroy Foster, '25, who became its acting director last year, was named director. Dr. Foster is also director of the M.I.T. Division of Sponsored Research, and was formerly a member of the Faculty of the Department of Mining and Metallurgy.

Baseball Coach

JOHN G. BARRY has become varsity baseball coach at M.I.T., succeeding Robert M. Whitelaw. Mr. Barry joined the Institute's coaching staff a year ago and is an instructor in the physical education program. He was graduated from the University of Michigan in 1942 with a degree in physical education, and has an impressive athletic record.

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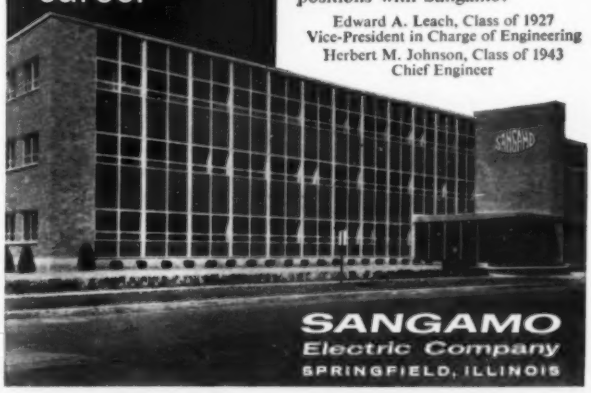

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- *The Image of the City,* **Kevin Lynch,** Associate Professor of City Planning, MIT.
- *Electronic Processes in Solids,* **Pierre R. Aigrain,** former Visiting Webster Professor of Electrical Engineering, MIT.
- *Methods of Regional Analysis,* **Walter Isard,** Chairman of the Department of Regional Science University of Pennsylvania. Previously of MIT.

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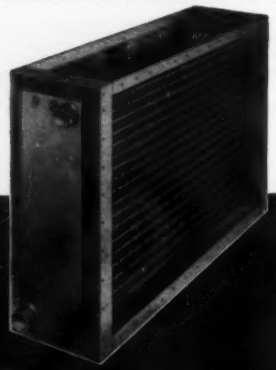

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Books

(Continued from page 38)

HORNS, STRINGS & HARMONY, by Arthur K. Benade, prepared under the direction of the Physical Science Study Committee; Doubleday Anchor, (95 cents). *Reviewed by Robert K. Mueller, '32, Associate Professor of Aeronautics and Astronautics.*

IF IT is correct to presume that the volumes of this series are intended as inspirational reading, to plant the seeds of profound thought in fertile and perhaps unsuspecting young minds, then the subject matter of this book offers a rare opportunity for great conquest. The existence in parallel of interest in science and music, the latter often deeply felt, has been observed often enough in productive minds in the past to be no oddity. One can imagine that the great Helmholtz, for all his Prussian austerity, could hardly have devoted the energy he did to virtually the whole spectrum of sound, subjective and objective, without a deep well of feeling for music as an art form.

The great opportunity here is that experience with wave fields in an ordered sense, involving an awareness of harmonic structure, has certainly been associated with sound far longer in human history than with any other phenomena. Until comparatively recently, light has been sensed rather as geometrical, with the sensation of color strong but isolated from mathematical thought. Now, of course, the two are becoming identified in microwave theory, and it is precisely here that the long history of musical instruments with empirically evolved forms, still not completely understood, seems like a natural precedent to the guides, cavities, and radiators which are becoming the distinctive features of communications systems.

The author, possibly as a matter of strategy with relation to his intended readers (who are unlikely to read reviews), has made nothing of this link. His approach is honest, open, and refreshing—clearly inspired by his own musical sensitivity. The early chapters in the book dealing with pendulums, simple oscillators, actual strings as limiting cases for strings of beads, etc., are well done; if passed over lightly here, it is only for the purpose of getting on to chapters on horns, theoretical and real. Here some really profound principles are deftly introduced under the guise of explanations of empirical features of practical musical instruments.

Since there are a number of examples of this, some picking at random is necessary. The discussion of "privileged" frequencies in brass instruments is an excellent example of subharmonic resonance where the lips achieve a co-operation with the air column at some fraction of one of the modes of the latter. Another example has to do with the open side holes in woodwinds, which form a musically more effective termination of the air column if they occur in groups of three or more. The purpose here is to achieve a similar impedance match, i. e., ratio of radiation to reflection, for the different harmonic components of a complex wave which tend to see a simple cutoff in a different way. The holes seem to act as an extended strainer which modifies the diffraction considerably.

(Concluded on page 62)

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Books

(Concluded from page 60)

There are a few pages of discussion of some little-known work of Bessel on useful bore shapes suggested by some work of his in astronomy. This will certainly go over the heads of secondary school students, if not of others, and apparently refers to propagation of complex wave shapes through a changing environment without change in form. This is an extremely important subject in long communications lines and was possibly inserted as a sleeper. In general, the "taper" of such lines where it exists in the vicinity of radiators is never expected to accommodate the frequency range of some rich musical tones and the problem, therefore, is less acute.

The book closes with a chapter on home-made wind instruments which is refreshing to read whether acted on or not. This is not to imply that it is offered for psychological effect only—the designs are practical and the sketches good, but not too good—but the result will certainly be to weed out the unfit, since considerable labor is involved. The conclusion of a prejudiced reviewer is that the book is well done but, more important, that the relevance of musical acoustics to other fields, notably microwave technology, deserves a chance to disclose itself to young readers of imagination.

Technical Books

RECENT publications likely to be of especial interest to M.I.T. Alumni include:

Direct Conversion of Heat to Electricity, edited by Joseph Kaye, '34, Professor of Mechanical Engineering, and John A. Welsh, '55, Assistant Professor of Mechanical Engineering, at M.I.T., and based on a special summer program given in 1959 (John Wiley & Sons, Inc., $8.75).

Electronic Processes in Solids, prepared by Roland J. Coelho, '59, and Gianni Ascarelli, '59, and based on lectures given by Pierre R. Aigrain while Visiting Webster Professor of Electrical Engineering at M.I.T. in 1957 (The Technology Press of M.I.T. and John Wiley & Sons, Inc., $4).

Information and Decision Processes, edited by Robert E. Machol, and containing contributions to a 1959 symposium by Claude E. Shannon, '40, Donner Professor of Science at M.I.T., and others (McGraw-Hill Book Company, Inc., $5.95).

The Internal-Combustion Engine in Theory and Practice (Vol. I: Thermodynamics, Fluid Flow, Performance), by C. Fayette Taylor, '29, Professor of Automotive Engineering (John Wiley & Sons, Inc., $16).

Properties of Elemental and Compound Semiconductors, edited by Harry C. Gatos, '50, of Lincoln Laboratory, M.I.T., and containing contributions by Lincoln Ekstrom, '57; Carol R. Kolm, '53, and Charles W. Mueller, '36 (Interscience Publishers, Inc., $8.50).

Photochemistry in the Liquid and Solid State, arranged and edited by Lawrence J. Heidt, Associate Professor of Physical Chemistry at M.I.T., and other members of a subcommittee of the National Academy of Sciences-National Research Council on the Photochemical Storage of Energy, and based on a 1957 symposium (John Wiley & Sons, Inc., $6).

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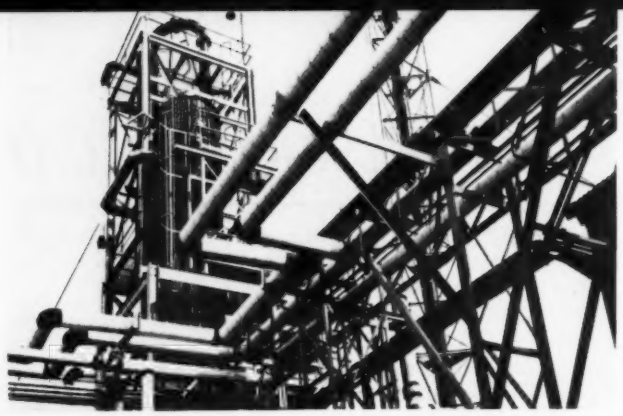

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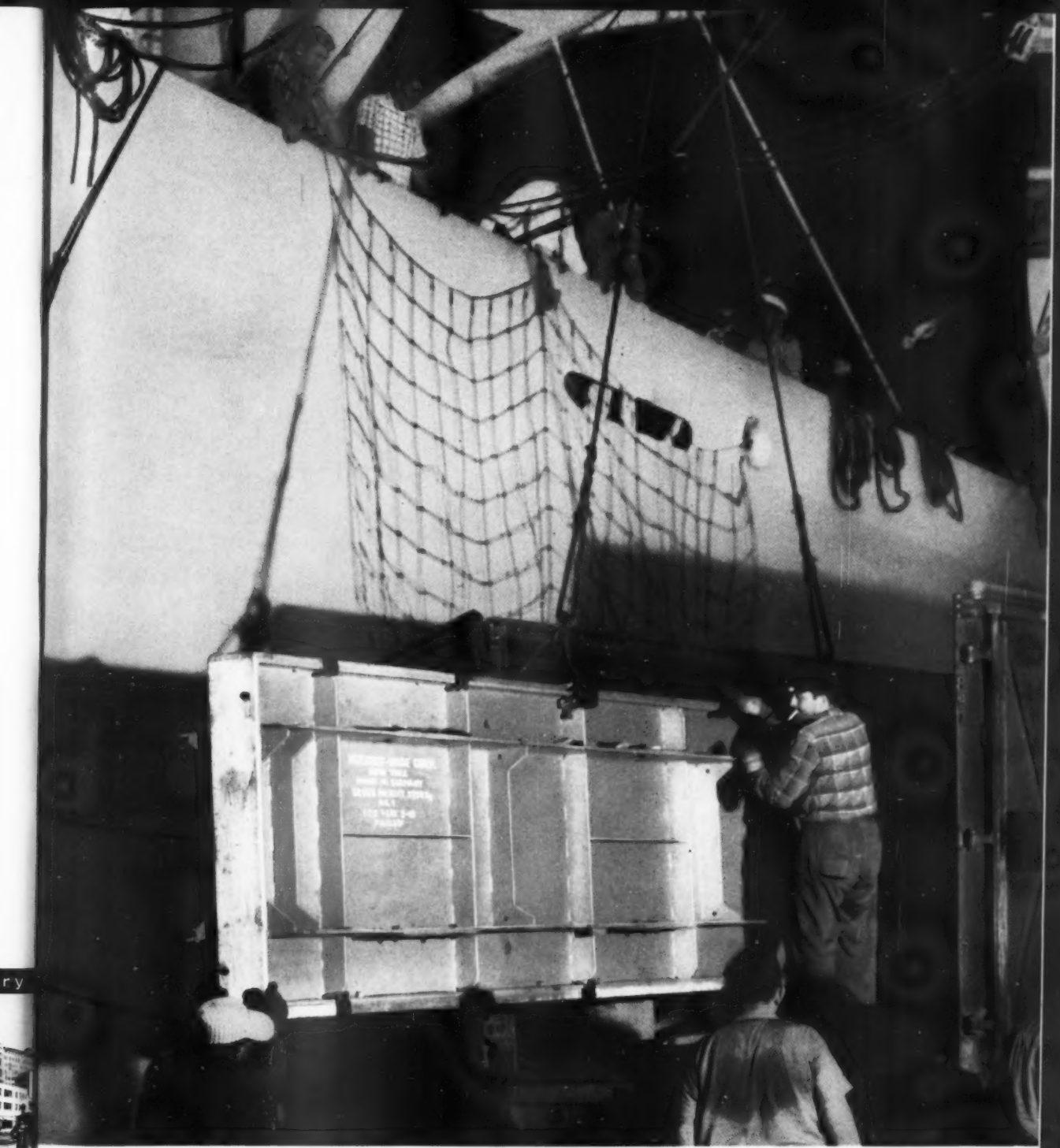

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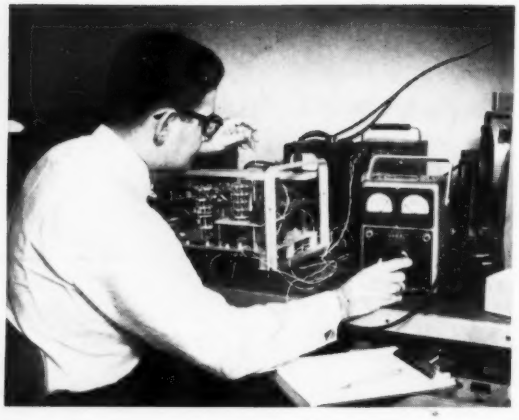

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